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A lecture delivered before the Franklin Institute and the Central Branch of the Young Men's Christian Association, Friday, November 21, 1902.

Two Years in Argentine as the Consulting Engineer of National Public Works.*

BY ELMER L. CORTHELL, SC.D.

(*Concluded from p. 235.*)

Coming to later times, new and illustrious names appear of men who were true patriots, who would not stoop to fraud or unbecoming political acts, and who, amidst the errors of their time and the temptations to do evil, came out pure as gold tried in the fire. One of these men is the author of the history of Belgrano—General Mitre, still living—the general who led the forces of Buenos Ayres in the last struggle for a united republic, and who may be called the "Father of his country," for under his wise governorship, his skilful generalship and wisdom as President, Sena-

* The lecture was profusely illustrated with the aid of lantern photographs.

tor and a public man always before the people, the country has been strong, united, prosperous and peaceful.

The sincerity of his motives, the purity of his life, public and private; his self-abnegation, his rigid honesty, his lofty ideas of public office, administering it always as a public trust; his modest and simple life—all explains why the entire nation recently honored his eightieth birthday, and why the statesmen of the republic sit at his feet to learn and to follow his wise counsels.

For want of time, I have refrained from developing the political history of the republic, or giving its earlier history—the discovery of the River Plate by De Solis, in 1515, giving the name of his second officer, Martin Garcia, to the now well-known island at the head of the estuary, or the discovery, in 1526, of the Paraná River by Sebastian Cabot and all the subsequent and checkered history of the Spanish-Portuguese rule in the River Plata countries. That they have passed through many trying periods, when the patriotism of the leaders has been severely tested, goes without saying. The heterogeneous elements, the ambitions of designing men, the lack of integrity in the early days of independence and the opportunities which selfish men had easily in their hands to enrich and raise themselves in political station, gave varied and not always envious political changes to decades of Argentine history, not necessary to inflict upon you now. Suffice it to say that the country has passed safely through those terrible ordeals. The principles of the 9th of July, 1816, in the Proclamation of Independence, and those laid down May 25, 1853, in the Constitution of the United Provinces, form the basis of the republic—fourteen provinces (states) and ten gobernaciones (territories)—principles which all hold sacred and which are almost exactly similar to our own.

The world, and especially its republics, owe more to Buenos Ayres than is generally known or recognized. The brief but eloquent summary of this period of its history by General Mitre shows how great has been its influence in the development of American national life:

"On the day, when the Chieftain Ramirez was routed

and slain, and that Varrera fled, seeking the sepulchre of his brethren, and that the farmers of Salta rose emasse to obey the order of the dying Gúemes, General San Martin, the 10th of July, 1821, was triumphantly entering Lima, and Bolivar, the conqueror of the north of Ecuador, was going at the head of the armies of Columbia to meet the Argentine liberator in order to seal the independence of the New World, already irrevocably assured by the occupation of Lower Peru, liberated by San Martin.

"Here ends the history of the independence of the Argentine Republic. If she was the precursor in chronological order, she was also the first to give the signal for the great insurrection which emancipated the Spanish-American Colonies from the mother country. It conquered its independence by its own efforts and without foreign help; it fought eleven consecutive years; it expelled its enemies from its territory, taking possession of their fortified places and conquering their squadrons upon the seas; it hurled back triumphantly upon the land the nine royalist invasions which endeavored to subjugate it. Its revolution is the only one which was not overcome, while all the others were, from Chili to Mexico.

"Devoured by anarchy, it struggled with it arm to arm, and at the same time carried its liberating arms to Paraguay, to the Banda-Oriental, to Peru, upper and lower, and its banners arrived victorious at the boundaries of Ecuador in the struggle for the independence of Colombia.

"Simultaneously its internal revolution took form, and upon concluding its second evolution with its own organic elements, the United Provinces of the Rio de la Plata, now in peace and re-organized according to the plan of an embryonic federation, which was to be the law of the Constitution in future, had sketched out its political map, tracing upon it with the sword of independence the inviolable line of its frontiers.

"It only remained for Jujuy, emancipated from Salta, to resume its federal autonomy, and to rise above the horizon the fourteenth star of this new national constellation. The Spanish power conquered, disorder dominated, and its

organic elements reorganized and reconstituted the Argentine Republic, which, even in the midst of anarchy, had contributed so much to secure its own independence and that of other South American nations was about to initiate a new propaganda of principles, which, like its armies, should spread over the entire South America.

"Buenos Ayres was the initiator and the herald of this new Pacific development. This province departed from its primitive plan of organization and gave up the impossible task of uniting the nation politically by means of revolutionary congresses and governments of irresponsible dictators which had shown themselves impotent to constitute and to unify the country. Concentrating itself within its own organic forces, it put in practice the idea of creating the type of a Federal State arranged on a constitutional plan, which should serve as a model to other provinces in the future. This initiation took place under the administration of General Martin Rodriguez.

"General Rodriguez called to his council, in order to realize the work of reorganizing, first, Bernardino Rivadavia and then Manuel José Garcia. These two statesmen carried it to a successful conclusion, with the coöperation of the same men who had fomented and sustained the revolution. Assuring independence and the re-establishing of order, they inaugurated the republican system in Buenos Ayres, breaking forever with colonial traditions; and they laid the foundations of a republican government which responded truly to liberty and progress. A limited legislative power was created, renewable on the base of universal and direct suffrage. The powers of the Executive were determined and its duration, and it was made responsible. Institutions of credit were established, and immigration and popular education were promoted. The income and the estimate of expenses were for the first time organized. The sciences and the arts were cultivated, absolute amnesty proclaimed and public opinion was given participation in the Government, and an extensive reform was carried out in all political and social institutions. In this manner was created the nucleus of Argentine, creating a republican

Federal State and making possible its organization in the future."

I stated in my remarks at Düsseldorf that the country was ambitious and determined to fulfil its destiny among the nations of the earth. I cannot close the political subject of my lecture without confirming this statement by the words found at the close of Mr. Mérou's history of Argentine, which he brings down to 1870.

"The Argentine Republic came out of this campaign (1870, with the dictator and tyrant of Paraguay) strengthened and united. The sentiment of nationality, crystallized by common sacrifices, was from that time forth an indestructible fact and a promise of days of prosperity and greatness, of a country united, free and powerful. We can contemplate the problems of the future with tranquility, consecrating ourselves with all of our intelligence and forces to build up with a broad and generous spirit and a disinterested love for truth and justice (following the traditions received from our forefathers and realizing their noble ideals) one of the greatest, most prosperous and most illustrious nations of the earth."

The United States, at a critical period in the history of South America (1818), presented fearlessly and firmly its pronounced views, and prevented a coalition of European powers for the purpose of compelling the American Colonies of Spain to return and thus re-establish Spanish domination in South and Central America and Mexico. Much to the surprise of the British Minister of Foreign Affairs, our Minister, Mr. Rush, boldly combatted the proposition by the statement that the decided views of his Government were, that the American Colonies of Spain should be completely emancipated from the mother country, and that in its opinion there could be no further outcome of the struggle which Bolivar and San Martin were engaged in on the Andean Plains.

As a concession to the American Minister, Lord Castlereaugh, the British Premier, stated that Buenos Ayres, (Argentine) among all the insurrectionary colonies, had given the best proof of its capacity to exist as an indepen-

dent nation, and its commerce had the greatest importance at the time and the best promise for the future. Our Minister in Paris, Mr. Gallatin, aided by Lafayette, was using his influence for the acknowledgment of the independence of the American Colonies of Spain. Our Government in 1818 was the first power of the world to recognize Argentine as a nation, by granting an "exequatur" to a Consul General appointed by that Government. This same country, having proven by its works its right to exist, now stretches out the hand to its benefactor of nearly a century ago and asks the interchange of products and its coöperation in its efforts to fulfil its high destiny among the nations.

It is pertinent here to remark, that the principle enunciated in 1818 with such quiet but firm determination, viz: That *America* is, and shall be, the undisturbed home of *Americans*, has persisted until the present day, and if attempts have been made at any time to impair the sovereignty of any American nation, there has always been a Grant or a Cleveland to frustrate them. President Roosevelt has recently clearly defined this much misunderstood principle, or so-called "Monroe Doctrine," when he said, "the nations now existing on the Western Continent must be left to work out their destinies among themselves," and "America, North and South, is no longer to be regarded as the colonizing ground of any European power." Thus it has happened that, while the Dark Continent has been partitioned among these powers, no hand as yet has been laid upon any part of America.

A correct interpretation of this "doctrine" is absolutely essential to a complete understanding and cordial accord between us and the other countries of North and South America.

An incorrect knowledge of it, particularly among the South American people, has engendered a popular antagonism to it as being unworthy of themselves to accept, without their consent, the suzerainty, or tutelage, of the United States, especially as their social and commercial affiliations are with European countries, from whom our Government has politically protected these republics for nearly a century.

Let us now take a bird's-eye view of the present Argentine, a country one-third the size of the United States, a climate salubrious and comfortable, of immense plains formed by Nature, as I have already shown, for the use of man—plains where the railroads find no natural obstacles worth mentioning in the way of their good alignment and construction; where we have, I think, the longest railroad tangent in the world, 186 miles, between Junin and La Cautiva, on the Pacific Railroad—plains covered with the cattle of the great estancias (ranches), thousands of them, of the best breeds in one estancia, and sheep by the millions, and great fields of wheat, corn and linseed, the principal agricultural products of the country. An "estancia" might be called a ranch on the great plains of our Western States. The size varies from about 3,000 acres to 700,000 acres; probably 25,000 acres might be considered an average size.

As might be expected, the business of cattle-raising requires expert men similar to our cowboys; they are called "gauchos." They are fearless riders and masters of ther trade. The horses they ride are generally rather undersized, but wiry and of great endurance. They are much like the best class of Mexican horses.

As the cattle roam over great ranges which are unfenced, it is necessary to brand them, as we also do on our great plains.

The homes on the estancias of the gauchos are not elegant, to say the least; but in the comparatively mild climate of Argentine they do not need as much protection from the weather as in many of our cattle districts of the Far West. They are a contented people, and while they do not have the facilities for entertainment which a city population has, they nevertheless have their fun on feast days, and whenever their arduous and roaming life will permit.

As might be expected of a country stretching through so many degrees of latitude and rising along the circles of longitude from the level of the sea to the highest Andes, there is a great variety of climate, and generally an abundant rainfall. Buenos Ayres is on the same parallel south of the equator as Wilmington, North Carolina, is north of it.

Snow is almost unknown, and scarcely ever is ice or frost seen. The climate in the summer is tempered by the great body of water of the River Plate.

The rainfall of Buenos Ayres averages 35½ inches per annum, about equal to that of the Northern States of the United States. At Asunción, Paraguay, it is 53 inches, about equal to that of New Orleans. The temperature is remarkably uniform. The mean temperature in June and July, 1899, the coldest months, was 54° F., and in January and February, the hottest, 76°; the annual mean being 62°. In twenty years the mean was 63°; summer, 77°; autumn, 65°; winter, 54°, and spring, 63°; mean of January, the warmest month, 79°; of July, the coldest, 52°. The extreme or extraordinary limits were 107° and very rare 104°, frequently 95°, and in winter 23°, which occurred but three or four times. In February, 1900, the heat rose to 103°, but the period of intense heat was only eight days. Such conditions are extremely rare.

A recent writer treating of tropical countries has truly remarked that "civilization is the product of geographical environment.

"If we divide geographical environment into its unchangeable and its changeable factors, we find the former to consist of climate, the configuration of the land, and the nature of the soil; and the latter of the surface conditions, which may be changed, for example, afforestation, deforestation, or agriculture; the situation of a country, the effects of which may be modified by the introduction of railways, steamships and telegraph lines; the unhealthfulness of a country, which may be counteracted to some extent by hygienic science.

"If we draw across a map of the world the northern and southern isotherm of 68° F., that is to say, a line passing through these places in the Northern and Southern Hemispheres which have a mean annual temperature of 68° F., we cut off a belt of the earth's surface 3,600 miles across, lying roughly between 30° north latitude and 30° south latitude. This belt is called, for the sake of convenience, the heat belt. In this heat belt lie Mexico, the Central Ameri-

can Republics, the West Indies, the greater part of South America, practically the whole of Africa, Arabia, India, Burmah, Indo-China, the Malay Peninsula, the Malay Archipelago, Polynesia and Philippine Islands. Outside the heat belt lie the United States, the United Kingdom, Canada, the greater part of Australia, Japan, the greater part of China, and the continent of Europe."

He might have included the southern half of Chili and the southern two-thirds of Argentine, as they are below the thirtieth parallel of south latitude, and the isotherm of 68° F. is 5° north of that of Buenos Ayres, which, as a mean of twenty years' observations, is 63°.

"The extreme significance of this grouping becomes apparent when we reflect that, apart from the work done by Europeans and Americans in the tropics, the civilization of the heat belt has remained stationary for a thousand years, and that the advancement of humanity during that period has been carried on entirely by the inhabitants of these countries which lie outside the heat belt.

"Bearing in mind the elements which go to make up our own civilization—Western civilization, so called—it is most important to realize that during the past 500 years, to go no further, the people of the heat belt have added nothing whatever to what we understand by human advancement. The natives of the tropics and subtropics have not during that time made a single contribution of the first importance to art, literature, science, manufactures or inventions; they have not produced an engineer, nor a chemist, nor a biologist, nor an historian, nor a painter, nor musician of the first rank; and even if we include half-castes and such natives as have enjoyed European education, the list of eminent men produced by the heat belt can be counted on the fingers of one hand.

This reasonable statement places Argentine among countries of a temperate climate, and shows why it and Chili are strong and progressive.

The *agricultural*, *industrial* and *commercial* features are those of greatest interest, and yet, to give you an adequate idea of them, I must give you figures, and they are not

always interesting; but an intelligent audience prefers them to any "glittering generalities," desirous of knowing what Argentine really is and has.

The population of the whole country is now about 5,000,000; its present rate of growth per decade is about 40 per cent., the United States is 20 per cent., Germany 16 per cent.

The Province, or State, of Buenos Ayres, is as large as Illinois, Indiana, Maryland, Connecticut and Massachusetts combined, or two and one-half times as large as New York State—120,000 square miles, and mostly plains, with 750 miles of coast line. It has 1,200,000 inhabitants, 10,000,000 head of cattle, 80,000,000 sheep and 2,000,000 horses. In 1901 it raised 862,000 tons of wheat and 1,360,271 tons of corn—a respectable showing; and the value of agricultural and pastoral products was $740,000,000. The wheat area of the republic, mostly in four provinces—Buenos Ayres, Santa Fé, Cordova and Entre Rios—is about 8,500,000 acres. Eighty millions to 100,000,000 bushels of wheat are exported. The total area under cultivation in the republic in 1901 was 17,500,000 acres. The increase over 1891 was 136 per cent. The crops were: Wheat, 1,964,000 tons; linseed, 490,000 tons; corn, 2,134,000 tons. The total of arable land is 253,000,000 acres, of which 240,000,000 do *not* need irrigation.

In the whole republic there are over 30,000,000 head of cattle—the annual increase is 25 per cent.; 5,600,000 horses and 120,000,000 sheep. In the United States there are 62,000,000—the annual increase is 33 per cent.; 2,634,105 carcasses were sent to Europe as one item of export. There are 300,000 goats in the country.

One of the important industries of the country is the "saladeros," which from its name signifies salted or jerked beef and extract of beef, etc. Nearly $40,000,000 are invested in them. Brazil is the principal market. Over 1,000,000 head of cattle were killed for the saladeros in 1900. The meat-freezing factories exported 100,000 tons of meat in 1901. An important factor in the Argentine meat trade, and it may be said in the meat trade of the world, is the successful result of continued efforts to send chilled beef to Great Britain. The River Plate Fresh Meat Company started this

trade in 1901, exporting in that year 29,919 quarters of beef; and from January 1 to May 31, 1902, five months, it exported 38,148 quarters.

Since that date the imports into Great Britain have rapidly increased, and recent despatches from London relate how this new factor in the London meat market is alarming the Beef Trust of the United States, and the Australian shippers. Argentine is placing its chilled meat in London at a considerably lower price, and is competing successfully with meat from the United States.

As might be expected, the wool industry is very important, about 500,000 bales shipped to Europe being the export product—in the year 1901-1902, 31,000 to the United States and 28,000 to Great Britain.

Argentine is a protectionist country, and its resources for conducting the Government are largely raised from the customs dues. In 1899 the imports free of duty amounted to $14,769,933 (gold), and those subject to duty $102,080,738 (gold). The exports were $184,917,531 (gold).

The United States imports $300,000,000 per annum of sugar, hides, linseed, jute, hemp, wood and fruit, and $36,000,000 of wool and woolen articles. All of these are produced by Argentine, yet only $6,000,000 of the $336,000,000 come from Argentine, or 2 per cent.

The United States exports, including cereals, meat and live stock, about $920,000,000, and only about $10,000,000 of this go to Argentine, or about 1 per cent.; while Argentine's purchases of the same articles in England were $39,000,000, and $60,000,000 from other countries.

Reciprocal trade would open the United States to Argentine wool and treble the production in a few years. There should be direct lines to that country from the United States, and the time should be reduced from about twenty-seven days to fifteen or eighteen days. We should ship to Argentine our manufactures, our coal, pine wood, petroleum, etc., and we should receive from Argentine its wool, hides, grease, dried fruits, hard wood for tanning and dyeing, etc. Now, for want of return freights, steamers load at United States ports for Buenos Ayres and return via Liverpool to New York, frequently via South Africa.

In reference to wool, I have already stated that in the entire United States there are only about 62,000,000 sheep, while there are 120,000,000 in Argentine. In the province of Buenos Ayres alone there are over 80,000,000 sheep. It is a well-known fact that the ranges in the Far West of the United States, which are absolutely necessary for sheep-raising, are rapidly being reduced by the extension of our population westward, and the cutting up of great areas into smaller farms. Not only do the smaller farmers as they go West wage constant war with the sheep-herders, but the cattle-raisers do the same; so that the time is sure to come very soon when we will need the wool of Argentine. What this country should do with a great agricultural country like Argentine, capable of immense productions, is to receive its raw materials and ship to it our manufactured goods.

It is proper, in closing this part of the subject, to quote a short paragraph which appears in the "Argentine Year Book," recently published, from the pen of Mr. Ronaldo Tidblom, Chief of the National Department of Agriculture and Live-Stock Industry. In closing up a long and very important article in that "Year Book" on the agriculture of Argentine, he makes the following statement:

"Nature has undoubtedly endowed Argentine with advantages for agricultural and pastoral farming not to be found in any other country of the world, and it is not too bold a forecast to say that if the country continues to improve her natural gifts in the same degree in which they have been cared for and improved up to the present time, the day will come when the Argentine farmers will have absolute control of the world's food markets."

The money of the country is on a paper basis, and the minimum value of a dollar was fixed in 1899 at 44 cents gold, or 127 per cent. premium. The market value of a gold dollar expressed in paper money varies now between $2.27 and $2.34, and the gold dollar of the United States is at a 5 per cent. premium over that of Argentine.

Railways have had an extensive development. In 1867 there were 355 miles; in 1880 there were 1,563; in 1890, 5,862; in 1900, 10,601, of which 1,243 belong to the Govern-

ment and 9,358 to foreign companies. In length of line Argentine stands ninth in the list of countries, but as compared with the United States the mileage is about 5 per cent. The paid-up capital is $550,000,000 (gold). The total receipts in 1900 were $40,000,000 (gold). Comparing the railroads of Argentine with those of the rest of the world, we find that in Argentine the length of line per 1,000 inhabitants is 3·46 kilometers, while it is 4·86 in the United States, 0·93 in Germany, and 1·70 in France.

The great Southern, the Western, and some other lines are still making extensions, and the Southern has crossed the Neuquen River and is looking for a pass to cross the Andes.

There are three gages—5 feet, which is really the standard; 4 feet 8½ inches, and a narrow gage, usually about 3 feet 3 inches (1 meter).

The total length of telegraph lines is 28,000 miles, of which 12,000 belong to the Government. Compared with the United States, the Western Union alone has 192,705 miles of poles and cable.

One of the most interesting railroad lines now in construction is the Transandine, which, upon leaving Mendoza, follows the Mendoza River to its source and climbs to the summit of the Pass of the Andes, 3,900 meters above the sea level (13,000 feet). The Abt system of adhesion up to 2½ per cent. and then Rack to 6 per cent. is employed.

Some very interesting views can be had of the approach from the Argentine side. Lofty mountains, rugged slopes, rushing rivers and the Puente del Inca (the Incas' bridge), a natural bridge, formed evidently by the river breaking through a great deposit of cemented material, caused by an avalanche. The railroad is not completed, and some of the most difficult work is yet to be done.

Speaking generally of the railroads, they are well constructed, though good ballast on the great plains is lacking. The cars are like American cars, but the first-class day coaches are much more luxurious than ours. All the long-distance trains have comfortable sleepers; a buffet and dining-car goes with all through trains.

In regard to the industries of the country, while the main products are agricultural and the exports as well, important industries are slowly developing. While sugar is an agricultural product the fifty-one sugar-mills may be classed among the industries. In 1870 Argentine imported 22,000 tons, but in 1901 exported 58,000 tons. There are $52,000,000 invested.

There are over sixty breweries in the country. The annual product is about 440,000 gallons.

There are 182 distilleries; the alcohol is made principally from corn. The annual product is about 3,000,000 gallons.

Milling is a very important industry. The first flour-mill was built in 1580 in the city of Cordova; the first steam flour-mill was built in Buenos Ayres in 1845. In 1895, by the census of that year, there were 659 mills—234 worked by steam and 303 by water; the total amount of flour made was 383,147 tons. The country now exports about 80,000 tons, all in bags and mostly to Brazil, valued at about $3,000,000 (gold). At present the Brazilian market is giving a preference to United States flour because it arrives in barrels, which must lead to the same method in Argentine, although the wood suitable for barrel staves is very limited.

The wine industry is one of the most important. The soil suitable for grapes covers an immense area, extending from the Northern to the Southern Provinces along the slopes of the mountains. Mendoza and San Juan, west of Buenos Ayres, are, however, the best adapted to vine-growing. In 1900 there were 89,000 acres in vines, valued at about $10,000,000 (gold). The transportation of the wine by rail in 1901, in Mendoza alone, amounted to 160,000 tons, and the stock of wine in the wine establishments (bodegas) was 33,000,000 litres (871,000 gallons).

The dairy industry a few years ago had practically no existence, and nothing at all was done with the milk of the millions of cows in the country. Now, large dairies are springing up in all the pastoral parts of the country, and at present the neatest and most tempting places to enter in the city of Buenos Ayres are the white-painted, scrupulously clean places for drinking milk, scattered all over the city,

the milk being sent in from the great "estancias." These dairies are being built in the most approved style, and they prepare pasteurized, maternized, sterilized and all other kinds of milk preparations. The exports of butter alone in 1901 were 3,322,391 pounds; in 1895 it was only 880,000 pounds.

Iron and steel industries are important, although there is practically no ore or coal in the country. In 1895 there were 154 iron foundries and 166 repair-shops, with a capital of $15,000,000. Every class of machinery is now manufactured, even to small engines and boilers.

Matches: The tax alone in 1899 amounted to $2,000,000.

Tobacco: The excise tax on which and its products in 1901 amounted to $4,200,000 (gold).

Four million dollars (gold) are invested in textile manufactures, employing 6,200 persons; canvas factories $1,000,000 (gold), employing 2,000 persons and making 5,000,000 yards; and $10,000,000 in hat factories, employing 700 hands.

As to mining, there are valuable copper mines containing gold and silver, also rich veins of gold and silver, with recent discoveries of iron-ore; but these various products have not been developed to any great extent, due to remoteness from the railroads and the roughness of the country, making the exportation very costly. The total value exported in 1900 was $262,222 (gold); these minerals include gold, borax, copper, marble, silver-ore, lead-ore, etc.

After this cursory and possibly uninteresting statement of statistics, it is a relief to turn to the beautiful and a really great city of the world, Buenos Ayres, and give you a brief outline of its most important characteristics. First, a little history and more dry figures to give an adequate idea of its size and general features:

Its early history is full of trouble. Founded in 1535, destroyed and rebuilt; and then from 1650, when there were 400 houses, it grew slowly under the old Spanish regime, and, later, under dictators and bad rulers, it slowly advanced in spite of an unstable Government. In 1852, when the noted Rosas was turned out, it had 76,000 inhabitants. Chicago was just then passing through the hard trials of a

little Western town and had not more than 20,000 people. In 1864 Buenos Ayres had 140,000 inhabitants and Chicago about the same; in 1869, 178,000. But Chicago had already started on its phenomenal growth and reached over 300,000. In 1887 Buenos Ayres had 409,000 and Chicago 1,000,000.

In October, 1902, Buenos Ayres had 864,513, and it is growing at the rate of about 40 per cent. per decade. It is destined to reach the million mark by the year 1906. It is now the largest city in the world, south of Philadelphia, if we except Chinese cities.

Comparing its present rate of growth per decade with some other cities, we find the following: Greater London, 20 per cent.; New York, 37 per cent.; Chicago, 54 per cent.; Philadelphia, 23 per cent.; Greater Berlin, 19 per cent.; Buenos Ayres, 40 per cent.

The city is on the right bank of the River Plate, a sloping bank 50 or 60 feet above the level of water, rising up to considerably greater elevations in the center of the city. It is about 120 miles from the sea at Montevideo. Its area is one of the greatest in the world, 44,830 acres; Paris has only 19,280, Berlin 15,625, Hamburg 15,681, and Vienna 13,690. It would be a good day's journey to go around the city, as its perimeter measures 39 miles.

So far as the natural conditions permit, the streets are laid out in the form of a chessboard, and are generally about 360 feet apart from center to center. In the central part of the city the streets are narrow; it is difficult for three carriages to pass. There are, however, a few 33 feet wide, and one or two avenues about 100 feet.

The finest, and said to be the best-lighted street in the world, is the Avenida de Mayo, which is in the center of the city as to the numbering of the houses north and south. It has a fine asphalt pavement and double electric lights in the center. It was cut through the blocks a few years ago, from the Casa de Gobierno (Government House), near the port, to the thirteenth street, somewhat less than a mile. At the other end there is being built a beautiful Capitol Building that will cost about $5,000,000 (gold).

There are seventy-two parks and small areas outside the main streets, with a combined area of 1,400 acres. These parks are more tastefully laid out and more neatly kept than can be found in any other country in the world, Paris excepted. In fact, in many respects the city, in its streets, lights, parks and structures, resembles Paris, except that there are more one-story residences than in Paris. The prevailing style is Spanish, with a patio (a kind of open area) and the rooms all facing it, and in this patio a garden and fountain, when the proprietor is able to have it; if not, pots of flowers very much like the city house in Mexico. The style of the houses of the wealthy may be seen on Avenida Alvear.

The pavements are wood (nearly all hard, suitable wood of the country), asphalt, granite blocks, macadam and rubble. No city has better pavements in the central part. In the outskirts, however, much of the pavement is very bad and uneven, merely rubble, but immense sums are being expended in substituting rubble for granite blocks and asphalt.

There is no city anywhere with more lines of street-cars; in fact, with the exception of two streets, there is a line in every one of the principal thoroughfares. And leading out to the pleasant suburban towns—Belgrano, Palermo and Flores—there are electric lines similar to those in American cities, using the overhead trolley. In fact, all the equipment, from rails to trolley, comes from the United States. Very extensive changes are being made in all parts of the city, substituting horse-cars, for electric. There are now 275 miles of street-cars which carried, in 1900, 116,447,982 passengers.

There is a project and a national concession for a system of underground electric tramlines, connecting the three main railway stations with the Plaza Victoria and, in one direction, extending by a surface line far out in the country. If underground lines pay in any city in the world they will in Buenos Ayres, for the conditions are especially adapted to their easy construction, the material being suitable for tunneling, and a great mass of people crowded into the "center" with its narrow streets, where the present surface

movement is often extremely congested. A citizen of the United States has the concession.

In 1868 there was a terrible epidemic of yellow fever, due, in a large part, to unsanitary conditions, but immediately afterward the city began a very extensive system of water and drainage works costing $33,000,000 (gold), discharging the sewerage 15 miles distant, and the storm waters by great intercepting sewers, now being completed, into the river in front of the city. The city water-works take their water above the city where it is never contaminated. These works were designed by Messrs. Bateman and Parsons, engineers, of London, and the main constructions carried out under their supervision.

The water of the River Plate is healthful but muddy, and it is clarified in settling-basins before being delivered to the distributing reservoir built on one of the highest points of the city. This distributing reservoir is a work of art, covered with glazed tiles over pressed brick. These works altogether have made Buenos Ayres one of the healthiest cities in the world, as the death-rate proves.

Ten years ago, upon the completion of the main works, the mortality per 1,000 was 30, now it is 16½. This compares very favorably with other large cities. London has 19·2, Glasgow 21·6, Liverpool 26·3, Manchester 24·1, Dublin 30·4, Paris 20·1, St. Petersburg 24·7, Vienna 20·7, Madrid 30·1, Rome 17·6, Venice 22·8, New York 18·4, Philadelphia 18·6, and Brussels 17·9. The Government is soon to extend the works at a cost of $5,000,000 (gold).

The climate, taking the whole year round, is equable and very agreeable. The parks are always green; vines and palms and a species of banana plants are seen everywhere, and flowers all the year in the open. It has a semi-tropical country in the north and in Paraguay from which to procure the plants, where the Victoria Regia and other beautiful plants grow wild.

In reference to education, the primary education is compulsory from the age of nine to fourteen; the secondary education from fourteen to nineteen is optional, as also the university or higher education from nineteen to twenty-five

or twenty-six. No man can enter into any of the professions, including engineering, and take a prominent position in the Government without being a graduate of the National University and having taken the course outlined in the above division of ages.

In 1900 there were 450,000 pupils in the public schools, which are free to all, and free to people of all religions. Although the Catholic religion is the national religion, neither it nor any other religion is allowed to be taught in the schools.

In the National University there are four faculties—law, and social science, medicine, exact physical and natural science, and philosophy and letters. In 1901 there were 3,562 students in the university.

In reference to religion, everywhere in Argentine under the Constitution all may worship God freely, according to the dictates of their own conscience. While the Government itself, like the Governments of Great Britain, Germany, Switzerland, etc., recognizes an established Church and assists in its maintenance, it also often assists in any benevolent and educational work undertaken by other denominations.

A very important work of this kind is the Argentine Evangelical Schools, initiated, promoted and carried on by Mr. William C. Morris. The report of 1901, just issued, shows there were 1,820 pupils in the various departments; in the previous year there were 1,076. This school is really a national school, and is assisted in a measure by Congress, although largely dependent upon private subscriptions, which are made to it not only by Protestants, but leading Catholics as well. It is devoted entirely to the education and care of children of the poor who cannot enter the public schools for want of suitable clothing.

The general style of the city is cosmopolitan, in buildings, in stores, in residences, in dress, in habits and customs of the people. It is made up of many nationalities. According to the census of 1895, there were in the country about 3,000,000 Argentines (all children born here of foreign parents are Argentines), and about 500,000 Italians—by far

the largest number of immigrants, and they are far better than the immigrants of the same nationality that come to the United States. Some of the best and most intelligent people in all kinds of business and industries, especially in agriculture, are Italians; next come the Spaniards, about 200,000; next the French, somewhat less than 100,000; next the English, 22,000; next the Swiss, 15,000; and lastly, the North Americans, as we are called, 1,400. These figures refer to the year 1895; the number of foreigners in the country December 31, 1899, was 1,199,808, an increase of 20 per cent. on the returns of the year 1895. Immigrants in the last forty-four years, 1,935,077; Italians, 1,198,550; Spaniards, 361,074; French, 162,636; British, 34,031.

The history of the lighting of streets in the city is very interesting, and shows that the city keeps pace with others in this respect. The first record of public lighting was in 1778, when the city had lamps in the shape of a tin of horse-oil with a wick, then came tallow dips, then oil-lamps, then came gas in 1885, and in 1888 electricity began to replace it in part, and on December 31, 1900, the city was lighted with 889 arc-lamps, 318 incandescent of sixteen candle-power, 14,084 gas lamps, many with the Welsbach burner, and 8,590 kerosene lamps, and there were thirty-six electric-light stations, with a capital of $9,000,000 (gold), and with a capacity of 23,300 electric horse-power.

In addition to telegraph lines there are four cable companies working with Europe and the United States, keeping up a close connection with all parts of the world, though the cost of cabling is quite heavy—$1 (gold) per word. The service is very good and prompt; its time of transmission between Buenos Ayres and London, "via Galveston" and Western Union lines and cables, is about sixty minutes, and with New York thirty minutes. When we consider the distance and the route, we are astonished at the working of this line, which crosses over the Andes 12,000 feet above the sea level, tunnels under the snow and avalanches and reaches the Pacific Ocean, only to take successive leaps by loops along the Coast to Tehuantepec, in Mexico; over the Isthmus, across and under the waters of the Gulf of

Mexico to Galveston, speeding then its swift flight over the poles of the Western Union to New York City; and then, without stopping to rest, plunges into the depths of the Atlantic Ocean and talks to the receiver in London in sixty minutes after it left the operator's fingers in Buenos Ayres. By a wonderful invention of recent years, this message has passed from ocean to land many times and back to ocean without stopping, through a "human relay," a machine worked by a human being.

It is an interesting fact that the difference in level between the highest point on land of the lines of the Central and South American Telegraph Company and the lowest point of its cables in the Pacific Ocean is about 31,000 feet (6 miles).

This company has three underground cables which cross the Andes and work uninterruptedly, notwithstanding that they are covered with snow, in some places at great depth, for about eight months of the year.

The house-fronts, when kept in repair and painted, are neat and architecturally beautiful. The words "repair" and "painted" must be explained. There are no wooden houses, which these words might imply; they are almost always made of rough brick covered with what is called "revoque," a covering of plaster or "staff," and sometimes artificial stone. The better class of houses generally have a base of granite, marble or other natural stone 3 or 4 feet high, and then brick covered with revoque. Sometimes the natural stone extends to the second story, and then invariably comes the artificial covering; after a while, two or three years, this begins to discolor and flake off, requiring painting and repairing; after ten years it begins to become an "eyesore," and at the end of twenty years it must all come off at very considerable expense. An instance to be cited is the American Church, Methodist Episcopal, which was built twenty-five years ago, but for five or six years past it has presented such a dilapidated appearance, that it has become necessary to remove the revoque from the sides and front from the base to the steeple, and renew it at a cost of $10,000—a large sum for a poor church.

A question came up recently about the Congress Palace just mentioned, as to what should be the external covering of this grand structure. Fortunately, the commission of engineers to pass upon this and other qestions decided upon a marble covering, and their decision was approved by the Government.

One of the finest constructions now being finished, after standing incompleted for ten years, is the beautiful Theatre Colon, which, through the kindness of Mr. Meano, the architect (who is also the architect of the Congress Palace), I am able to show you from some slides he has sent me.

The means of locomotion about the city are abundant—street-cars everywhere, and a very good and economical cab service. There are few coupés, no public hansoms and only one or two private ones; but the street carriages are two-horse victorias which carry four people. The private turn-outs are equal to those of any city in the United States, especially the horses, which are of the best imported stock. The "Corso" and the approaches to it on a Saturday or Sunday afternoon are very attractive. It is in the beautiful park of Palermo, one of the suburbs, broad avenues, beautiful shrubbery, lakes and shady drives, and immediately in front the broad River Plate, whose further shore is beyond the horizon.

The people show great taste in the arrangement of their stores, and particularly the shop-windows; from a butcher's shop to a confectioner's and a lace store, the fine French taste is visible everywhere. A walk along Florida, the principal shopping street, a fine asphalt street with no street-cars in it, is one of the delights of Buenos Ayres, and one never tires of it. If, for a fortnight, you miss this promenade, you hardly know the street, for the appearance of the stores has greatly changed in the meantime by a complete change of the decorations.

The manner of living is continental, not even English—a cup of coffee with a roll in the early morning; breakfast at 11 to 12.30 (which is a meal in courses), and dinner at 7.30, the principal meal of the day. This is the custom among all classes, high and low; and there is another custom (it is

strange how soon you fall into it): tea or coffee or matte—a species of steeped herb (yerba) pressed into a peculiar little bowl and sucked out of it with a hollow stick called a matte stick. This 4-o'clock drink is as necessary as any meal. In the Government House (Casa de Gobierno) the Government provides tea or coffee for all of its officials and employees, and little rooms are seen in various parts of the building, where it is made and served from, always accompanied with some kind of delicate biscuit.

Perhaps some current prices may be of interest, remembering always that, to get the price into American money, you must take only four-tenths of the price to allow for the discount.

Foreign letter postage is 15 cents per ½ ounce (6 cents).

Domestic letter postage, 5 cents per ½ ounce (2 cents).

Telegrams for the first ten words, 5 cents (2 cents), and the successive words 3 cents (1·2 cents). Telegrams in any other language than Spanish, double price. Address and signature are counted, as in Europe.

The usual fare for a victoria is a dollar (40 cents gold), whether you take it by the course or by the hour.

The foreign debt of the National Government in 1900 was $336,771,614 (gold), and the internal debt $3,222,500 (gold). There are thirty different loans, the interest on which ranges from 3½ to 6 per cent.; the total interest charge per annum in 1900 was $22,349,900.84 (gold). It requires annually to pay the interest on the total debt $18,661,864 (gold) and $11,695,218 (paper). The annual charge per each inhabitant is about $6 (gold).

It is generally known that in 1897 a terrible financial crash came upon the country, at the time of the Baring failure; since then it has had to struggle to carry the load imposed by the disasters of those days; however, perhaps not more disastrous than happened to Chicago in 1893, as many will attest who were caught in the Columbia National Bank failure and others.

What language is spoken? Spanish, which is the national language; but, as might be expected in a cosmopolitan city, French, Italian, English and German are spoken almost everywhere, particularly French.

As English money and Englishmen have done more than any to develop the country, have built and run nearly all the railways, many of the great estancias and other businesses, particularly commercial, the English language is very generally used in railroad and navigation circles.

With these general characteristics of the country and the Capital City, I must give you a brief résumé of the ocean commerce which has done so much for the country, and situated as it is, at these antipodes of the world, so necessary. First, a few dry facts and then the description of commercial facilities.

In 1899 the value in gold of goods imported was about $117,000,000, exported $185,000,000. Of these, $44,000,000 imports came from Great Britain, and $15,000,000 from the United States; Italy comes next with $14,000,000 and Germany next with $13,000,000, then France with $11,000,000 and Belgium $9,000,000. But exports show a different distribution, for France took $41,000,000, Germany $29,000,000, Belgium $24,000,000, Great Britain $22,000,000, the United States $8,000,000 and Italy $5,000,000. Of the foreign trade, Buenos Ayres had 87·2 per cent. of the imports, Rosario 8·8, La Plata 1·2 and Bahia Blanca 0·80. Of the exports, Buenos Ayres had 55·5 per cent., Rosario 18·4, La Plata 2·30 and Bahia Blanca 7·00. These ports are mentioned, as some information about them is needed to explain the commercial situation. Of all the goods reaching the River Plate countries, 80 per cent. comes to Argentine.

In 1885 the National Government began the construction of very large docks at Buenos Ayres; hitherto, all the business had been done from the anchorage, about 12 miles from the city, the intervening space being a great mud-bar, the water from a depth of 25 feet gradually shoaling to the shore-line at the city. This was so flat that it was necessary often to transfer the passengers and goods from the lighters, with which they had come thus far from the vessels, to steam launches, then to small boats and then to great wheel-carts, that went out a long distance in the water to meet the boats.

The new docks are very extensive, and lie along the

immediate front of the city and connected with it; they were designed by the well-known English firm of engineers, Hawkshaw & Hayter, and carried out under the supervision of Mr. James Dobson, the resident engineer and partner of the firm. The concessionaire was an Argentine citizen, Mr. Madero; the contractors were the experienced firm of Walker & Co., who built the Manchester Ship Canal. These men deserve the highest credit for carrying through, under the financial difficulties of the period above mentioned, a great public work costing $38,000,000 (gold).

In order to reach the docks from the sea, a channel had to be evacuated in the mud foreshore from the anchorage. This channel (the north one) is at low tide 21 feet deep and 330 feet wide and about 5½ miles long from its intersection with a channel which already existed by previous dredging from the other end of the port, at the mouth of a small sluggish stream called the Riachuelo, in which channel there generally was about 19 feet of water at low tide. The tide of 2 or 3 feet, depending largely upon the direction and force of the wind and very uncertain, permits vessels drawing about 23½ feet to enter the port by the north channel. The new port was connected with the older port, and now both channels are being used, and the depths in them are about as I have stated.

The Government has recently begun the extension of the north channel straight out to the anchorage, and later will deepen it to 22 feet. In the meantime, the navigation uses a crooked channel beyond the intersection, which has been partly dredged, curving round from the south channel to the anchorage. The depth of water in the northern entrance basin of the port is 21 feet, but in the four great docks, 23 feet, with tidal gates, so that the vessels at low tide may be afloat.

The works are built in the most substantial manner—masonry walls founded on what is called "tosca" (loess), the hard substratum that is found in this part of the country. The four docks, or basins, are from 620 to 750 yards long and are all 170 yards wide, connected by passageways 22 to 27 yards wide, over which pass, by hydraulic turn-

ing bridges, the foot, vehicular and rail-traffic. A sea-wall in front protects the entire port. On the city side are three and four-story brick warehouses, twenty-four in all, with a total frontage of 1½ miles. Sheds, cattle-yards, railroad tracks, hydraulic cranes and capstans and other important appurtenances give the port modern facilities for handling cargo.

When the docks were opened at the southern end in 1899 the registered tonnage of vessels arriving and departing at the port of Buenos Ayres was 3,800,000; in 1901, 8,661,299—more than 100 per cent. increase. There are only twelve ports in the world of greater tonnage, and none of them show such phenomenal growth.

In 1880, about the time that the works were proposed, the tonnage was 644,570, and the plans were made for 2,000,000 tons only.

The extraordinary growth of the commerce has made it necessary to make an enlargement of the facilities, and this was one of the works intrusted to me during the last year of my stay in Argentine. I am able to show you the general plan of the actual port with the proposed enlargement, which will have free access from the sea and a depth of 26 feet.

The plan also provides facilities for "inflammables"—petroleum, gasoline, naptha and some explosives.

The Standard Oil Company, of New York, is now arranging to bring bulk oil in tank steamers to Argentine, and the Shell Transport Company is preparing to make a specialty of the importation of fuel oil from Texas and the Dutch East Indies. The work of enlargement of the port is divided into sections, so that it can be carried out section by section, as the increase of commerce will require. The general plan also includes the protection and deepening of the entrance channels.

One of the principal ports of the country is Rosario. Ocean navigation reaches it, and, for that matter, reaches Colastiné, the port of the city of Santa Fé, the capital of the province. The registered tonnage of the Port of Rosario in 1899 was 3,000,000, of which more than 2,000,000 were over-

sea vessels—about 700 per annum. The merchandise entered and cleared was about 1,650,000 tons. Sixty-seven per cent. of the exportation was wheat. In the busy months there are often over thirty vessels seen at one time along the wharves and the barranca, where the wheat is loaded in bags, sliding down from the high cliff 60 feet above the vessel, in what are called "canaletas." The imports amount to about $10,000,000 (gold), and the exports to $30,000,000.

The National Government is making a great port of Rosario, endowed with all modern facilities for handling cargo. It sent out to Europe and the United States a full report, with all necessary data, submitting the project to capitalists and contractors, with the request for propositions to build and operate the port. It will cost from $10,000,000 to $12,000,000 (gold).

The contract, after an examination of and report upon the projects presented by a board, of which I had the honor to be president, has been let to the well-known and experienced firm of contractors, Messrs. Hersent, of Paris, associated with Schneider & Co., of Creusot—the Krupp of France. The works of construction were inaugurated by the President of the Republic, on October 26, 1902.

The plans of the work have been based on the data above mentioned.

Some important problems had to be solved in connection with the improvement of so great a river as the Paraná, the bed of which is subject to such important changes, and also its islands and banks.

The front-line of the proposed wharves is over 2½ miles long. The masonry piers must go down into the tertiary sand below the scour of the river, and their foundations will be from 60 to 80 feet below the low-water level.

The importance of this work, furnishing a modern seaport to the second city of the country, can scarcely be overestimated. In my report on the project made in September, 1900, I used the following words, which two years of subsequent study have corroborated:

"It is safe to say that the establishment of a first-class port at Rosario, with suitable channels of access, will revo-

lutionize completely the commerce and industry of this Republic."

I can now show you some interesting views of the river, the shipping, the canaletas carrying grain, the grain piles and some of the more important buildings of the city. All the plates made on the best American glass and by an American photographer, Mr. F. P. Danforth, of Boston, who has lived many years in Rosario, and I may add that many other slides shown you to-night were made for me by him.

La Plata port and city were built by the Provincial Government, when, in about 1880, the National Government came to Buenos Ayres to occupy it as the capital of the nation. It is an excellent port; it is built on the shore of the Rio de la Plata, about 35 miles from Buenos Ayres, and cost about $14,000,000 (gold). The opening the national port at Buenos Ayres has drawn most of the commerce from La Plata, but it is capable of being made, with a comparatively small sum of money, deep enough, in its entrance channel (5 miles long) and in its port areas, to accommodate vessels of 26 feet draught at low tide; it now has 21 feet.

The remaining port of importance, and rapidly growing, is outside the River Plate, in the South—Bahia Blanca; it is the principal shipping port of agricultural products by the Great Southern Railway, the largest system in the republic. This port is in an estuary of the ocean, and is a protected harbor; in fact, the terminal of the railway is about 35 miles from the open ocean. The railway is building a steel pier, 1,640 feet long, with spacious warehouses and 19 miles of sidings; and there will be, when all works are completed, over half a mile of wharf frontage supplied with electric cranes.

The National Government is building in this estuary at Puerto Militar, or Puerto Belgrano, a system of dry-docks and basins on a large scale. The first dry-dock, one of the best and largest in the world, is completed and now in use. It was designed and built under the immediate supervision of the well-known Italian engineer, Chev. Luigi Luiggi, who had charge of similar work at Genoa.

This dock, built of first-class materials and upon the most

modern methods, can take the largest naval or merchant ships of the world, as it has a useful length of 713 feet, and an entrance width of 85 feet, and a depth over the sill of 32½ feet at mean high-tide. It has intermediate gates, so that two or three small vessels can be docked at the same time or separately.

I cannot here go into details of construction, which were fully given in a paper on the subject submitted by Mr. Luiggi to the Ninth International Navigation Congress, at Düsseldorf, July, 1902. He has very kindly given me over thirty lantern slides, of which I can show you a few to give you a general idea of the dock. The plans, photographs and, possibly, a relief model of the dock will be exhibited at the World's Fair in St. Louis, in 1904.

In October last the U. S. Battleship Iowa, the flagship of the South Atlantic Squadron, was docked at Puerto Militar.

You will be interested to know that at Buenos Ayres there is a large business with New York by means of five steamship lines, and through New York with Chicago and other cities, from which are shipped a large amount of agricultural machinery of all classes, from cultivators and plows to great steam threshing-machines of the J. I. Case Company, of Racine, Wis. Not only from Chicago, but from all manufacturing districts, the trade of our country is quite rapidly increasing. You see our machinery everywhere, and it is everywhere considered equal to any—Baldwin locomotives, Jackson & Sharp cars, and Harlan & Hollingsworth's. The American freight-car of 25 and 30 tons is replacing the old Belgian, French and English 7 and 10-ton cars. If the American cars are not all made in the United States they are exactly copied from ours. The most approved bridges are from the United States. I have been over several, and examined one on the Transandine Railway, built by the Phœnix Bridge Company—excellent bridges and giving entire satisfaction. The Boston Bridge Company sent out some very good bridges; the horse-cars, by John Stephenson & Co., of New York; electric-cars, by the J. G. Brill Company and the Westinghouse Company, are doing well there. Large quantities of Southern and Oregon pine are imported.

From the United States comes all the kerosene used in the country. I might go on enumerating many other United States products. I can well say that the prospects of American trade with Argentine are exceedingly good.

The total population of Argentine, 1902, is about 5,000,000; so that, as you see, about one-sixth live in the capital city.

I would like to enter into the work of the engineers, but cannot now. I may say, however, that the Argentine Government is determined to improve the great rivers of the country by methods which have been found to be best in other countries under similar conditions. The results of our experience upon the Mississippi are being closely watched, studied and applied. The reports of the Mississippi River Commission are of great value to that country. I may further say that the engineers, and the methods pursued by them, are equal to those of any country. Every Government engineer, to take a prominent position, must have a diploma from the Engineering Department of the National University. The graduates of this excellent school are as well equipped for their work as those from any school in the world—this I know by experience, for four of them (young men) have been associated with me as my immediate assistants; and in my position as Consulting Engineer of the Government I have been brought into close relations with many other engineers, and I have the highest opinion of their ability.

I will now select at random a few subjects of special interest, and a few lantern slides.

The Government Building—Casa Gobierno—sometimes called the "Casa Rosada," from its light-rose color, and in which was my office, is one of the most prominent buildings in Buenos Ayres.

It stands in a prominent and central position, facing the Avenida Mayo, and looking out on the other side over the port and the River Plate.

One of the finest structures in Buenos Ayres is the "Prensa" Building, devoted entirely to that morning paper. I know of no newspaper offices in the world that can com-

pare with this in elegance and convenience in all its interior appointments.

The leading newspapers of Buenos Ayres are equal to any, both in editorial ability and in telegraphic news from all parts of the world.

The Sarmiento School gives me an opportunity to call your attention to one of the most learned and best of presidents, who, when he was Minister at Washington, became so enamored of our country, and particularly our educational methods, that he engaged a large number of our young lady teachers to go to Argentine as Normal School teachers. Many of them are there yet, after nearly twenty years' service—a service that has reflected honor upon themselves and their country.

An institution of importance is the Jockey Club, for by its influence the Argentine blooded stock of horses has been made equal to any in the world, and its domicile is one of the finest and most expensive of any club-house in existence, and its stand at the race-course of Palermo is a beautiful structure.

Some views of Recoleta, the principal cemetery, will show you the general method of burying the dead.

Before closing this lecture, it is right for me to say that considerable of the statistical data was obtained from "The Argentine Year Book," just issued for the first time (1902), and that some of the hydraulics are from a contribution to that book written by myself. The Annual can be obtained from the Moorgate Publishing Company, of London.

You may properly ask me why I have brought before you the subject of Argentine. I can easily reply: First, because in two years of close relations with the country, and especially with the Government officials, I formed a very favorable idea of the character of the people and of the possibilities of business and profitable enterprise for our own people there; and, second, because the high officials of the Government and leading men of the country desire to have the "North Americanos," as we are called, come to Argentine with their business energy, integrity and ability, and their capital as well, to help build up and move forward to its high

destiny that great country of South America, so like our own in its climate, soil, rivers, coast-line and other general features.

If I have succeeded in interesting you in Argentine, and of giving you more knowledge of it than you had before, I shall be satisfied with my efforts and feel that I have done a service to that country and to my own, and I will close by introducing to you General Roca, the President of the Argentine Republic.

FURNACE GAS ENGINES.

The construction of gas engines to burn the gases of blast-furnaces probably represents even more important economical changes than those for utilizing either natural gas or producer and illuminating gas. Germany has held undisputed supremacy in the development of this form of engine in the past few years, and we are just beginning to profit by her experiments. Engineers look to the German operators for their designs and tests with the blast-furnace gas engines, but now that they are perfected it will not be long before a complete change will be effected in this country. With our numerous blast-furnaces scattered all through the country, it is essential that the installation of engines to utilize the waste gas should be made at once. The gas engine of 1,000 horse-power is no longer a dream. It has been steadily developed and improved by the tandem system, so that it can be operated by blast-furnace gas of but 27 calories per cubic foot. As as result of this development, the blast-furnace suddenly assumes an entirely new line of development. It may be that the production of pig-iron will in the near future become only of secondary consideration, and the gas for operating engines the chief factor of the works. The blast-furnace gases are sufficient to run powerful engines even when discounting half for waste and for heating the air-blast of the furnace.

The amount of gas generated by a blast-furnace to produce pig iron is so enormous that if collected and utilized for power purposes it would prove revolutionizing in manufacturing industries. Thus to produce in an ordinary well-equipped works about 150 tons of pig iron, the blast-furnace would generate upward of 20,000,000 cubic feet of gas. To harness this enormous amount of waste fuel is the aim of the builders of gas engines. Utilized for generating steam by burning, about 1,000 horse-power could be obtained; but if burnt directly in a modern large gas engine, the horse-power generated would be several times as much. Eminent engineers estimated that even if half this volume should be wasted or used for heating the air-blast of the furnace, there would still be sufficient to produce between 3,000 and 4,000 horse-power. Such an enormous gas generator would thus prove of the greatest value for ordinary manufacturing purposes. Likewise, the gases of coke ovens can be utilized in the same way, adding greatly to the importance of the gas engine in its new field.—*Iron Age.*

Mining and Metallurgical Section.

Abstract of a paper presented November 20, 1902.

On the Industrial Importance of Metallography.

By Albert Sauveur.

The lecturer, after expressing his belief in the industrial importance of metallography, said that he was fully aware that many who had only a very superficial and fragmentary knowledge of the subject were inclined to question its practical side. He hoped that he would be able in his short talk to present such arguments as would be, if not conclusive, at least suggestive of its commercial application. As he had been prevented from preparing a paper on the subject, he hoped his hearers would extend to him the indulgence of which he was in need. It was possibly best to assume that some of the persons present did not even have a rudimentary knowledge of metallography, and to shape his remarks accordingly. Time would not permit to consider other metals than iron and steel.

The lecturer used a number of enlarged photomicrographs to illustrate his remarks. He first called attention to the structure of pure gold, which consisted of irregular polyhedric grains, stating that all pure metals exhibited a structure of this character, the size of the grains, however, varying with different metals and also with their treatment, especially with the temperature to which they were heated and with the rate of cooling.

Passing to the structure of pure or carbonless iron, it was shown that this metal also was made up of irregular polyhedric crystalline grains, its structure being very similar to that of gold or to that of any other pure metal. It was noticed, however, that some of the grains were dark while others were bright, and this was shown to be due to the fact that each grain is made up of a great many small cubic crystals which have the same orientation in the same grain

but are differently oriented in different grains. Those grains which have their small cubic crystals so oriented that they will reflect the light in the tube of the microscope will appear bright, while if the light reflected by the small crystals fails to enter the tube of the microscope, the corresponding grains will appear dark. It was seen, then, that iron and other metals were composed of crystalline grains, each grain being made up of a great number of small true crystals, frequently cubic.

Passing to the microstructure of wrought iron, it was shown that it also consisted of a mass of crystalline grains, but that the structure included beside numerous particles of slag. In a section cut in the direction of the rolling or forging of the iron bar, these slag particles ran parallel to that direction imparting a fibrous appearance to the metal. In a cross-section, however, the slag occurred in the shape of irregular small areas corresponding to the cross-sections of the fibers exhibited in the previous diagram. It was thought for many years that wrought iron actually had a fibrous structure and, indeed, the number of persons still holding this view was surprisingly large. Many valuable properties were attributed to puddled iron on account of its "fibrous structure," which were denied to steel because of its "crystalline structure." The microscope had summarily disposed of this erroneous belief in showing that the carbonless iron constituting the bulk of wrought iron was just as crystalline as the carbonless iron constituting the bulk of soft steel.

Carbonless iron considered as a microscopical constituent had been called *ferrite*. In introducing a small amount of carbon in the iron, say 0·10 per cent., and in producing it molten so as to obtain it free from slag; in other words, in converting it into soft steel, the structure underwent an important modification: the bulk of it was still made up of ferrite but it contained besides a number of small dark areas which necessarily must contain all of the carbon present in the metal. These dark areas, however, do not consist of pure carbide of iron, for upon higher magnification the constituent is resolved into two components: it is made

up of parallel plates alternately dark and light. These plates consist of ferrite and of the carbide, Fe_3C. This carbide had been called *cementite*, while this new constituent, consisting of a mixture of ferrite and cementite, was called *pearlite*, because of its pearly appearance. A number of photographic enlargements were exhibited illustrating the structure of pearlite.

Upon increasing the amount of carbon in the steel, the amount of pearlite increased and that of ferrite decreased, correspondingly. When the iron contained about 0·8 per cent. of carbon, the ferrite had entirely disappeared, the metal consisting then entirely of pearlite. Upon a further increase of carbon, the steel still consisted of a mass of pearlite, but particles of pure cementite were now present which increased in proportion with the carbon content, while the pearlite decreased correspondingly. The rationale of the structure of steel could evidently be explained as follows: All the carbon present in steel entered in combination with some of the iron to form the carbide Fe_3C which contains 6·67 per cent. of carbon. This carbide or cementite formed a mechanical mixture with some of the iron, in the proportion, roughly, of 1 part of cementite to 7 parts of iron (ferrite), assuming the shape of pearlite. If an excess of iron was left over, it was present in the structure as ferrite, and this would be the case with low carbon steel: if, on the contrary, an excess of the carbide was present it was found in the structure as free particles of cementite.

Passing to the microstructure of cast iron, the lecturer showed that perfectly gray iron was composed of a mass of ferrite throughout which was distributed numerous particles of graphite, while white cast iron had the structure of a very high carbon steel, being made up of pearlite and a large amount of cementite. It was, indeed, not possible to draw a sharp line of demarcation between high carbon steel and white cast iron. The structural changes occurring in the structure as the carbon increased was a very gradual one, from the softest steel to the hardest grades and finally to white cast iron. It was then shown that when gray cast iron contains a small amount of combined carbon, the matrix

of the metal contains a small proportion of pearlite—in other words, it consisted of low carbon steel; as the carbon increased in passing gradually from the perfectly gray to the white variety, the matrix or metallic part of the metal underwent exactly the same changes which had been shown to occur in steel under similar conditions. Cast iron consisted of a mass of steel plus a certain amount of graphitic carbon. The lecturer took exception to the oft-repeated statement of some writers referring to the great complexity of cast iron as compared to steel, and expressed his belief that if cast iron was viewed in its true light, it would greatly help in solving many puzzling problems.

The close relations between the structure of steel and its treatment on the one hand, and between the structure and the properties on the other, were then dealt with somewhat at length, the lecturer illustrating his remarks by photographs of the same steel which had been subjected to a number of different treatments. The composition of the metal had not been changed, and if given to the chemist the latter would have had to report that the various samples, from a chemical standpoint, had the same properties. Their properties varied greatly, however, and were closely related to the appearance of the structure. This demonstrated the limitations of chemistry and the assistance which may be expected from the microscopical examinations in all questions relating to the treatment to which metals are subjected; and it was of as great importance to impart the right structure to a metal as to secure for it a desirable composition. The harm resulting from a defective structure was as great as that resulting from a defective composition.

Concluding his remarks the lecturer stated, that if any one, in taking up metallography, expected that he would be able to solve all his daily troubles, and to solve them at once, he would be disappointed; but that if the study was taken up in a more reasonable frame of mind and conducted intelligently, it could hardly fail to prove of very great assistance.

The lecture was further illustrated by the exhibition of some stereopticon slides. The necessary apparatus to carry on metallographical work was exhibited, the lecturer being

greatly indebted to the Ajax Metal Company and to the Cramp Shipbuilding Company for the loan of apparatus.

DISCUSSION.

MR. P. KREUZPOINTNER.—Mr. Chairman and Gentlemen: It is a great pleasure for me to corroborate all that Professor Sauveur has said about the use of the microscope in examining metals, so far as its practical value is concerned to the expert, in a variety of ways where the chemical analysis and physical test fail to give us a satisfactory explanation of certain phenomena.

I have used the microscope for the past eighteen years, and I consider its use as valuable and indispensable an addition to a physical laboratory as the plane is to the carpenter, or the micrometer is to the machinist. I do not share the optimistic view, though, of some, that in the near future we may be able to use the microscope as a substitute for the chemical analysis or the physical test. There is such an endless variety of conditions that affect the structure of, say, a piece of steel, which might lead the microscopist to judge that, with the change of structure, a change in the physical quality, or ability of a given steel to do a given piece of work, has taken place. Such an assumption, however, does not hold good, as two pieces of steel of different structure may and do give the same tensile strength, and the one which is inferior often gives a better elongation even, due to greater stretch at the point of rupture and less stretch along the section. Thus, in my opinion, and judging from experience, it will be some time yet before we can tell the working qualities of steel without other means than the microscope. Moreover, even then, whenever we should reach that desirable point of perfection and simplicity in method of determining the qualities of metals, for a long time to come there would be but a few experts who would be able to do so with reliability, since the determination of the quality of iron and steel for their physical ability to resist the forces of destruction, requires long experience and the opportunity of everlasting comparison of metals of all kinds and of all makes, new and old, made by the same

manufacturer at different times, or different manufacturers at the same time For these reasons the microscope, valuable and indispensable as it is, as an auxiliary to the physicist, will not become a substitute for the tensile test for a long time to come, although the tensile test is not by far so reliable as many engineers assume it to be. The best and most reliable service the microscope has done thus far, and is destined to do still more so in the future, is in the determination of the heat-treatment of steel and the composition of alloys which have not yet undergone mechanical treatment.

With the hammering or rolling of metals a complexity of conditions arise, to determine which requires a greater variety of means and personal practical experience. Concerning the question, subsequently raised, whether the appearance of the coarse fracture of a piece of steel, or rather metal, that is of the fracture as it originates by nicking and subsequent breaking, or breaking in service, bears any relation to the micrograin or microstructure underneath the fracture, I do not believe there is any relation between the respective layers or planes of the metal sufficiently well defined that we could draw conclusions from the appearance of the fracture to the microstructure below, or the succeeding plane of the metal.

In order to allow us to draw conclusions from the fracture to the microstructure underneath, we must assume that the distortion of the particles or crystals of the metal, caused by the rupture, would continue deep into the metal, so that succeeding transverse planes of the metal exhibit the same amount and nature of distortion, which then will be the micrograin in question. If we assume that no distortion of the particles takes place during rupture, which, however, is inconceivable, since in that case we would have to assume that there was no resistance offered by the metal to the force of rupture, then still the appearance of the ruptured surface would be so much different to the naked eye than the micrograin underneath, that we are not warranted to draw any conclusions more than to say that the metal underneath is fine or coarse-grained.

From what experience I have in regard to this question, I would say that the distortion, caused by rupture, does not go beyond that amount of metal which we have to file and grind off in order to get to the plane of metal below the rupture plane, and, therefore, what we see in that plane with the microscope is not what we see in the grain of the ruptured surface of the metal. The unreliability of conclusions drawn would, of course, be the greater the farther we go away from the point of rupture, because of the variations of microstructure we are apt to find in any piece of commercial metal in its various portions or sections.

MR. W. R. WEBSTER inquired whether the appearance of the fracture of a piece of steel, as seen by the eye, corresponds with that under the microscope?

MR. ROBERT JOB:—In answer to Mr. Webster's question whether the appearance of the fracture of a piece of steel, as seen by the eye, corresponds with that under the microscope, I am satisfied that in the large majority of cases it does do so. In other words, when the fracture appears to the eye coarse-grained, the steel has a coarse microstructure. It has been our experience that the converse is not invariably true. A case in point came under our observation several years ago in making drop-tests upon a lot of rail-butts. All had been rolled under the same conditions throughout, yet, when fractured under the drop, some showed a coarse granular fracture while others appeared to be relatively fine. Sections were removed from some of the latter, and they were found to have the coarse, open, microstructure characteristic of that rolling. Therefore, I feel that deductions from an apparently fine-grained fracture may be totally at variance from the actual structure, and that the fine granular form may be merely incident to some peculiarity in the conditions of fracture.

When the fractured surface is filed smooth and etched, the granular appearance, as viewed by the unaided eye, is relatively the same as when seen under the microscope, and a general estimate may often be made without the aid of the glass.

MR. G. H. CLAMER:—The structure of alloys presents many of the characteristics exhibited by cast iron and steel. In fact, we may regard these as alloys of iron with varying amounts of carbon, silicon, manganese, etc. One of the most simple examples by way of comparison is the lead and antimony alloy, which has by experiment and microscopic examination been shown to consist of dendrites of pure lead embodied in a eutectic of lead and antimony, if the content of antimony be below 13 per cent.—the saturation-point of these two metals. As in steel, free ferrite is contained in diminishing proportions from pure carbonless iron up to ·89 per cent. carbon. Just as from pure lead to the alloy of 13 per cent. antimony, or thereabouts, is the free lead present in diminishing proportions. At 13 per cent., so-called eutectic alloy, lead is saturated with antimony, antimony is saturated with lead. No free lead is present, no free antimony. As the proportion passes the eutectic composition, free crystals of antimony make their appearance. Here again we see the analogy to steel, which segregates above the saturation-point of ·89 per cent. carbon-free cementite.

Another interesting example is the alloy of copper and tin, which has, perhaps, a little more complex composition. Alloys rich in copper (above 73 per cent.) consist of dendrites of pure copper eutectic and chemically combined copper and tin, generally conceded to be of the formula $SnCu_3$. The above alloy, 27 per cent. tin and 73 per cent. copper, is the first eutectic, the high tin-content alloy forming another. The formation of these eutectics exhibiting themselves constantly in the everyday manipulation of alloys has a very practical bearing on foundry practice.

I once met with a very peculiar demonstration of the presence of copper and tin eutectic in casting phosphor-bronze, a composition which contains 79 per cent. copper, 10 per cent. tin, 10 per cent. lead and 1 per cent. phosphorus. This metal was cast into connecting-rod bushings for locomotive construction. The castings showed on the outside a thin skin of metal about the thickness of paper, which could readily be detached from the casting, showing

it had been forced to the surface through pores after the body of the casting had solidified. The composition of this was about as follows—I cannot locate the exact figures:

Copper	70 per cent.
Lead	3 "
Tin	22 "
Phosphorus	3 "

thus showing perhaps a quadruple eutectic, or, at any rate, a tendency toward the copper-tin eutectic—27 per cent. tin and 73 per cent. copper.

Another curious thing in connection with this was the presence of 3 per cent. phosphorus, showing the fact discovered by Charpy, that phosphorus is localized in the eutectic.

Another curious phenomenon coming daily under my observation is the formation of eutectic on top of compositions, such as the above, in casting ingots. An alloy of metal, when apparently solidified, will often have appear on its surface what we term eutectic sweats, because it sweats or oozes out in thin streams apparently through pores, and forms globules on the surface. These globules are hard and brittle, and entirely dissimilar to the main portion of the ingot, the analysis always showing a high tin alloy, although the original may contain but 5 to 10 per cent.

I can heartily endorse this apparently new method of investigation, for which Professor Sauveur has done so much in this country, and can say that its field of usefulness is not confined solely to the province of iron and steel, but can be extended also in a practical way to the manufacture of metallic alloys.

PLATINUM EXTRACTION IN THE URAL REGION.

Professor Demaret-Freson has lately published some interesting facts in regard to the production of platinum. Within the last few years the applications of this metal, especially in the electrical industries, have rapidly increased, while the production remains about stationary, and it is estimated that the entire world's production is not over 7 tons annually. It is owing to this cause that there has been a considerable rise in the price of platinum.

The metal is generally found in alluvial layers of sand and gravel near the water-courses, in the bottoms of valleys or on the hillsides. It generally occurs in the form of flattened grains with either a rough or smooth surface. Nuggets are also found, but these are more rare. Russia furnishes about 96 per cent. of all the platinum produced. It is found especially in the Ural region, the most productive locality being in the government of Perm. The placers are situated on the crest of the mountain chain or on the two sides. On the European side they lie along the rivers Vilva and Kava and along the Otka and other streams. Many of the rich placers lie in the domains of Prince Demidoff, and on one occasion a nugget was found there which weighed 22 pounds. The platinum-bearing strata are often 15 feet in thickness, but as they are often sunk as low as 60 feet below the surface, they must be reached by a series of shafts and galleries. On the Asiatic side are found the gold and platinum-bearing sands of the Miass River and other streams of the region. The richest deposits yield from 60 to 90 grains of platinum per ton, while this proportion varies down to 40 grains The metal is generally found along with gold in most of these regions, and both are extracted by a somewhat primitive method. When the material is of a clayey nature, it is charged in a barrel-shaped wooden receptacle about 6 feet high and 8 feet in diameter, whose bottom is covered with perforated sheet-iron. Into the cylinder is fed a number of streams of water from a pipe which encircles the mouth. In the center turns a vertical shaft carrying a series of arms which support iron bars for working the material. In this way a muddy deposit containing the metal sinks to the bottom and passes out through the holes; it is run on to an inclined table or shallow trough 3 feet wide and 10 feet long, in which are retained the platinum grains. In other cases, when the material is sand or gravel, a simple cylindrical sieve is used instead of the cylinder and, like it, is supplied with streams of water.

When the placers are found in the river-bed or in submerged ground, the peasants employ a primitive method of dredging. Mounted on a raft, they operate a wood scoop through an opening in the center. The scoop is on the end of a pole 12 feet long, and is brought up by a chain wound on a windlass. The sand and gravel are poured on a sieve which is mounted above a kind of cradle placed on the raft itself; it is fed with water from a hand-pump. The material obtained by these processes is further enriched by a second washing, and the platinum is separated by treatment with mercury, which amalgamates with the gold but does not attack the platinum, and the residue containing the latter is sent to the refineries. The residue obtained in the Ural region contains on an average 87·25 per cent. platinum, 1·20 of rhodium, 0·05 of iridium, 0·01 of osmium, 1·04 of palladium, besides 1·50 of osmium iridium alloy; it also contains 8·40 of iron and 0·55 of copper. To extract the platinum from the mixture, the wet process is generally used; it is treated with aqua regia, and the solution thus obtained is precipitated by chloride of ammonium in the form of a double chloride. The latter is calcined and the resulting product may contain 99·9 per cent. of platinum In some cases the electric method is employed to separate the platinum from the iridium and rhodium. A rather weak current is used, the electrolyte being an acid solution of platinum chloride.—*Scientific American Supplement.*

Section of Photography and Microscopy.

Stated Meeting, held Thursday, February 14, 1903.

Under and Overexposure.

By John Bartlett.

There is undoubtedly truth in the saying, "a fellow-feeling makes us wondrous kind," so far, at least, as photographic experience is concerned, for we all sympathize in the disappointment of those who fail from the one cause of improper exposure of plate. At the risk, therefore, of being laughed at for uttering a photographic truism, we would hint at the paramount importance of correct exposure. Notwithstanding the confidence some have in depending upon the so-called latitude of exposure, we are of the belief that this latitude is within very narro v limits.

There is demanded a correctness in estimating the time of exposure, if any regard is had to the beauty or brilliancy of the result.

To the inexperienced eye the effect of a slight deviation from correct exposure may not be perceptible in the resulting negative, but to the trained eye a very slight excess of timing is apparent in the solarization of the high lights and the clouding over of the shadows, which become more or less emphasized in the print.

Correct exposure, therefore, should be the aim of the photographer, and we are inclined to think that this *desideratum* is attained only by exercise of judgment gained by experience. For one acquires, by observation of the varying effects of light upon a variety of subjects presented to the camera, a sort of photographic sense which serves him in future experience. There have appeared from time to time many ingenious attempts to reduce the time of exposure to rule. Instruments have been constructed and tables calculated to guide the inexperienced.

Far be it from us to speak disparagingly of any means promising to put exposure on a scientific basis, so as to

reduce to exactitude our photographic work; but personally we, after trial, have found them wanting.

The conditions under which subjects must be photographed vary so considerably, not only as regards light and shade, but with the character of the subjects, that any attempt at calculation would involve the consideration of so many factors as to preclude any systematic arrangement, and would contribute rather to the confusion than to the edification of the novice.

A record of personal experience is of more value in training judgment than implicit reliance upon exposure-meters or tables. Nevertheless, it may be urged that judgment is liable to err, and mistakes may be even made by the experienced, which it may be desirable to counteract in development.

If the time has been correctly estimated and the developer tempered thereto, any one may work out the plate's salvation without fear or trembling; but when the personal equation of under or overexposure is taken into consideration, the evolution of the perfect negative becomes really a fine art, and foreknowledge and acquired skill are demanded if one looks for softness without smear, high lights distinct and well defined, and shadows full of detail going by imperceptible gradations into the lights.

How shall this knowledge of proper adjustment be acquired? By experience we have said, not by mere dosing with bromide of potassium, deluging with water or spurring with alkalies, nor by feeling one's way with the leading-strings of tentative development.

Some start out on the very cautious track; thus, not knowing the exposure, they say let us bring out the detail with weak pyro or eikonogen or other agent, and then pile it on afterwards to build up by intensity.

Others say, start with the minimum of alkali, and if undertiming is evident, then apply the increments of alkali. By both plans experience attains good results, and the votaries claim that their special method is the only practicable method of manipulation.

But "there will come a time some day" when your ten-

tative method will be found wanting. To get good results, we ought to diagnose the plate's exposure and determine whether the case demands a direct method in development or a tentative method, and apply a special therapeutic.

We hardly appreciate the resources we have in our phalanx of modern developers. We know a good deal about their action but take little advantage of their special agency, thinking that they may be used indiscriminately.

Pyro is still a faithful ally in many cases, especially for obtaining plucky, vigorous negatives with rich shadows; but when great detail is demanded, and we are not sure that ample time for shadows has been given, it would be unwise to cling to it and try to force detail by excess of alkali when better results may safely and effectually be obtained by one of the other reducing agents like metol, for instance.

Suppose we wish to develop an exposure in which we have certain colors which unequally affect the sensitive film—that is, we desire to equalize the action of light impressed upon a plate not orthochromatic. It certainly would be unwise to employ a strong development, which would cause the rush of particles to the parts most acted upon by light and give the negative the appearance of an undertimed plate. No. We should rather make use of a well-diluted developer in which the alkali was somewhat in excess of the reducing agent.

But how are we to treat an enforced short exposure? We must seek for a developer which shall work out all the detail which the light has impressed. For really we are of the belief that it is not so much the failure of the brief impact of light on the silver molecules to produce effect as it is the inability of the developing agent to marshal them to its calling. We believe that any, no matter how brief, action of light produces a molecular change, and it is only the want of a proper reducing agent to make the action of the light manifest. In other words, if we had suitable developer we might evolve an image made by the briefest possible exposure. So it is by very short exposures we are apt to get very contrasty negatives if we are not exceedingly cautious

in our methods of development. Where the action of the developer is slowed, there is a more harmonious distribution of particles, and consequently a greater range in gradation of light and shade than could be obtained by a rapid development. Any agent, therefore, which is slow in its action recommends itself for short exposures. Glycin, an agent but little used simply on account of its tardiness in evolving the latent image, is preferable for undertimed plates.

The advantage of glycin over pyro and others is that with short exposures it gives less dense high lights and richer shadows—that is, its slow action equalizes the distribution of light and shade.

Various agents have been employed either as retarders, restrainers or accelerators of the action of the developer in calling forth the latent image.

We are familiar with the use of potassium bromide as a corrective of overexposure. It is, indeed, a valuable accessory to development, but its injudicious use frequently results in the production of harsh, contrasty work, inharmonious in light and shade.

Citric acid has been suggested as a restrainer in place of potassium bromide. When the modern developers are used, it will be found that a 10 per cent. solution of the acid gives greater power of restraint and less contrasty effect than bromide, and, besides, not materially affecting the duration of time of development. Sugar, in the form of weak syrup, is also employed to restrain hasty action of developer.

Among the accelerators of the action of the developer, the writer has found iodine of especial advantage. A developer with iodine may be made as follows:

Water	3½ ounces
Sodium Sulphite (granular)	62 grains
Hydroquinone	15 grains
Saturated Solution Sal Soda	2½ drachms
Bromide Potassium, 10 per cent.	10 drops

To this solution is added 3 drops of iodine solution made with—

Water	4½ drachms
Iodide of Potassium	77 grains
Iodine (scales)	20 grains in 8 ounces water

This accelerates development of undertimed subjects in a remarkable degree, and the resulting color of the image is richer and more intense than without the use of iodine. The addition of iodine, even in slight excess above that recommended, is liable to cause fog and reduction of density.

Hypo has also been used as an accelerator (1-1000), very dilute, of course. In some cases it may be found beneficial, but the writer has not noted any special advantage from its use.

We have spoken of the advantage of slow development for undertimed plates and of the employment of diluted solutions. Indeed, some operators employ exceedingly diluted developing solutions for snapshot work in the form of what is called "tank development." The plates are placed vertically in a bath and covered with a solution containing only a small quantity of developing agents—so small a quantity that it is necessary for the action to be continued a long time to produce good results. The writer has subjected plates very much undertimed to a developer so constituted that it required twelve hours to obtain satisfactory negatives. Pyrogallic acid seems to lend itself best to this mode of development, as it may be diluted to a great degree without losing its energy; its action is only slowed down. Of course, there is danger of encountering stain by prolonged exposure of film to pyro, and it is necessary to employ an increased amount of sodium sulphite in the bath. Edinol, one of the late additions to the list of developers, may also be greatly diluted without appreciable loss of energy. It must be used in connection with sulphite of soda, but there is less liability to stain than with pyro.

AMERICAN INVENTION IN 1902.

The report of the Commissioner of Patents for the calendar year 1902 shows a total of 49,490 applications for patents, including designs, and that 27,776 patents, including designs, were issued. In addition there were 110 patents reissued, 2,006 trademarks registered, and 767 labels and 158 prints registered. During the year 23,331 patents expired, 4,471 applications allowed were forfeited because of non-payment of fees, and 9,284 allowed applications are still awaiting final fees. The excess of receipts over expenditures was $159,514.

FORMATION AND MALADIES OF PEARLS.

Pearls are concretions formed of carbonate and phosphate of lime, associated with a small quantity of animal matter. They are produced by various acephalous mollusks. They consist of very thin layers of mineral matter, arranged in such a way as to give rise to the phenomena of interference, producing that brilliancy and orient which have made them sought for in all ages as objects of adornment.

Their origin and formation have been much discussed. Without recounting all the poetical legends to which they have given existence, naturalists seem to infer that they may be formed in any part of the mollusk. This notion is erroneous.

All pearls are formed by the mantle, and it is only afterward and by accident that they are found in other parts. The examinations of the *Unio* leave no doubt in this respect.

The identical chemical composition of the internal nacreous layer of the valves of the mollusk and of the pearls corroborates this view.

The walls of a bivalve shell are composed of two layers, each having a special origin. (1) An epidermic layer, produced on the border of the mantle, and forming its organic continuation. (2) An internal layer, composed of very thin lamellæ, secreted by the external surface of the pallial envelope.

The first of these layers increases the periphery of the valves; the second augments their thickness.

It is in consequence of a lesion, or the presence of a foreign body, organic or inorganic, that a depression is produced in the pallial surface, with a hypersecretion of nacreous matter, forming concentric layers around the foreign body as a nucleus. The concretion, thus formed, usually remains at first adherent to the pearly layer of the corresponding valve and separates from it later, becoming free. This action of the pallial surface explains the process employed by the Chinese for the production of small nacreous bas-reliefs. It is sufficient to introduce the surface to be pearled between the mantle and the internal face of the shell, making the reverse of the relief adhere to it in some way.

Pearls can ordinarily be preserved for long periods without change. However, they may become *sick*, that is, undergo various modifications, causing them to lose the qualities on which their value depends.

These maladies are spontaneous or acquired. The first consists of a sort of disaggregation of the superficial layers produced slowly, and in the end destroying the brilliancy and orient of the pearl. It is possible to remedy the evil, at least for a time, by the removal of the affected layers, either by a chemical process or by mechanical polishing.

The acquired maladies are produced by prolonged or repeated contact with the skin, whose acid secretions and sebaceous matter exert a deleterious influence. They may also occur from the influence of gaseous emanations, sulphydric acid in particular. Pearls in time acquire a slight amber tint, which is far from diminishing their value; but when this tendency exceeds a certain limit, they become blackish, the organic matter being modified by the causes that have been mentioned. I know of no remedy then for the sick pearl, and believe that its depreciation is inevitable.—*M. S. Jourdain in Sci. Am. Suppl.*

Strength of White-Iron Castings as Influenced by Heat-Treatment.*

By A. E. Outerbridge, Jr.

In the year 1882, while engaged in metallurgical work at the car-wheel foundry of A. Whitney & Sons, in Philadelphia, my attention was called by the inspector of wheels to an unusual and remarkable change that had occurred in the chilled or white iron forming the "treads" of a number of wheels poured from one heat. This change was first observed on removing the wheels from the annealing ovens. It was customary for the inspector to prove the hardness of the chilled treads by testing them with a cold chisel all around the "throat" or place where the tread joins the flange. On this occasion he found a number of wheels which were quite soft on one portion of the rim, extending the entire width of the tread for a length of 6 or 7 inches, while on either side of the soft spots the chilled tread was so hard that the steel chisel slipped over the surface without biting. In order to study the nature of this singular occurrence I caused the wheels to be broken through the soft spots so as to examine the fracture, and I found that the white iron (chilled iron) had been changed into perfectly gray iron, evidently after the wheels had been cast. The change was not equally well marked in all of the wheels and the soft spots were smaller in area in some cases than in others, but in all, the dividing line between the white portion and the gray portion of the chilled tread was sharply defined.

It is perhaps necessary to state that in the establishment where these wheels were cast it was customary to pre-heat the annealing pits by means of soft-coal fires before the wheels were lowered into them, the flames passing through the pits or ovens. The rule was to close the dampers just

* Read at the fifth annual meeting of the American Society for Testing Materials, held at Atlantic City, June 12, 13, 14, 1902.

before the pits were opened to receive the red-hot wheels, in order to shut out the flames.

After careful investigation, I found that through an oversight the dampers of the annealing pits had not been closed and the flames from the fires impinged upon the surfaces of three or four red-hot wheels in the lower part of each pit, causing a complete change of the carbon from the combined form to the free condition wherever the flames touched the castings.

Drillings were taken for analysis from the soft parts of the chilled treads and also from other parts of the wheels, as well as from test-pieces poured from the same ladles of iron. The analyses showed two things—first, that the car-wheel iron was of normal composition; second, that the only change in the metal of the annealed or soft portion of the "chill" was in the condition of the carbon, which had been converted from chemical combination with the iron into an amorphous form of graphitic carbon, or, to speak more guardedly, I would prefer to say simply into the form of "free" carbon, for there are reasons for believing that the carbon in this case is not in the same condition as when it exists normally in gray iron.*

Specific-gravity tests showed that the gray cast-iron resulting from this accidental heat-treatment of white iron differed materially in density from the normal gray iron forming the unchilled parts of the same castings; the specific gravity was about 7·80 as compared with specific gravity of

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* Through purely chemical methods four conditions have been detected:

(1) Graphite or free crystallized carbon, not acted on by acids even when concentrated.

(2) Graphitic carbon or "temper-carbon," which is also in a free state and unaffected by acids, but presenting an amorphous appearance.

(3) The carbon of the carbide of iron (cement carbon) forming a definite compound, acted upon by concentrated acids, but insoluble in diluted cold acids. This carbide answers to the formula Fe_3C.

(4) Hardening carbon, which appears to form a solid solution with the iron (or which is perhaps present as a compound dissolved in the iron) and which is acted upon by cold, dilute acids.

"Notes on the Chemical Constitution of Cast-iron and Steel." By A. Carnot and E. Coutal.

Annals des Mines, October, 1900.

about 7·20 for the normal gray metal; a cubic foot of the gray iron produced by this annealing process therefore weighed about 37·5 pounds more than a cubic foot of the normal gray iron of the same casting. It was noticed that the fracture was of much finer grain than normal gray iron, and "chips" or drillings of the annealed chilled iron differed greatly in appearance, size and shape from the chips or drillings of the normal gray iron made with the same drill.

Several metallurgists, to whom the pieces of annealed chilled iron were exhibited, offered a plausible explanation of the phenomenon, saying that it was merely an accidental conversion of the white iron into malleable iron, and therefore presented no novel features. The analyses quickly showed the fallacy of this theory, for the total carbon was the same after annealing as before annealing, being about 3½ per cent. in each case, while in the ordinary conversion of white-iron castings into malleable iron, a large part of the carbon is removed by the oxidizing material in which the castings are imbedded when subjected to heat-treatment, and this conversion of white iron into malleable iron can only be successfully accomplished on sections of metal of moderate thickness, say less than 3 inches.

Although this accidental discovery of annealing of white iron on the treads of car-wheels was regarded as an interesting and novel one at the time, the only practical use made of it was to guard against a repetition of the accident in the annealing pits of the car-wheel works with which I was at that time connected.

After the lapse of several years I was called upon to investigate in a professional capacity, and in the interest of some prospective investors, the merits of a new process of converting white-iron castings into steel, and received from the manufacturer a number of axes, hatchets and other edge tools, which had been cast in white iron and subsequently converted into a metal having evidently many of the qualities of steel.

Without describing in detail the process to which these white-iron castings had been subjected, I may say, briefly,

that they were placed in the muffle of a furnace together with a chemical compound claimed to be necessary to the conversion of the cast-iron into steel. Common salt and crude hydrochloric acid were two ingredients of this compound. The similarity between this process and the accidental over-annealing of the car-wheels (with consequent change of the condition of the carbon) suggested to my mind that the chemical compound was probably unnecessary and that the secret consisted solely in the heat-treatment, and I so advised my clients.

The conversion of white-iron castings into dense gray iron having high tensile strength (approximating that of certain grades of steel) capable of being hardened and of taking a sharp cutting edge is no longer a secret, and is carried out on a commercial scale in a number of establishments. While I cannot speak positively, I am of the opinion that the heat-treatment alone is now relied upon to produce the desired results. These products are *not* steel castings, though sold in some instances under the name of steel; neither are they malleable iron, but they may be described as occupying a peculiar position midway between cast-steel and cast-iron.

Having given a résumé of the history of this process of heat-treatment of white-iron castings, I will state a few facts regarding certain interesting features, including tensile strength of this converted metal. In the early experiments I found that there was a vast difference in white irons, some samples remained white and hard after having been soaked for many days in the annealing furnace, even when subjected to the highest temperature below the melting-point of the metal, while other specimens of white iron of the same dimensions yielded readily to the heat-treatment and became completely converted into gray iron in a few hours at a comparatively low temperature—analyses of the different samples revealed the chief cause of this difference; it depends almost entirely upon the presence or absence of silicon in the white iron; castings containing only a trace (or a few tenths of 1 per cent.) of silicon cannot be successfully treated, for only a partial change of the combined

carbon into free carbon takes place, even after prolonged treatment at the highest temperatures. Thus, in one of my tests, two white-iron bars, about 2 inches in diameter and 12 inches long, were placed side by side in the furnace and subjected to the heat-treatment for eight hours. One of the bars, containing about 0·15 per cent. silicon, was cast in sand; the other, containing 1·25 per cent. silicon, was cast in a heavy iron mold, because, if cast in sand, it would not have been white iron. Both bars were equally brittle, equally hard, and perfectly white before treatment; a slight tap with a hand-hammer was sufficient to break them. When removed from the furnace after eight hours soaking at a high heat, and allowed to cool in the air, the bar containing 0·15 per cent. silicon was unchanged in the appearance of the fracture, while the bar containing 1·25 per cent. silicon was almost gray; it was soft and so ductile that a small piece of it was flattened out under the steam-hammer while cold. The bars were then returned to the furnace, subjected to the same heat-treatment for six hours longer and allowed to cool, as before. No visible change occurred in the low silicon bar, while the other bar was completely converted into gray iron with a uniformly fine-grained fracture and dark-gray color. This bar was turned in a lathe to a diameter of 1·129 inches (giving an area of 1 inch) and provided with threaded ends for the grips of the testing-machine. The metal was readily machinable and the surface was free from "graphite pits" so characteristic of ordinary soft gray iron when machined. This bar was pulled on a hydraulic testing-machine of 100,000 pounds capacity, and the actual load at failure was 47,760 pounds. The elongation and reduction of area were not measured, but were very small.

A number of similar tests were made on different sized bars, giving tensile strengths ranging between 40,000 pounds and 50,000 pounds per square inch, but manufacturers equipped for making converted castings in this way have obtained much higher records than these.

The literature upon this novel and interesting subject is very limited, but some valuable papers have been published

and it is my desire to present herewith a résumé of the work done by several well-known metallurgists in this country and in Europe.

At the meeting of the Mining and Metallurgical Section of the Franklin Institute, held June 9, 1897, Mr. Charles James described "A Special Process for Treating Cast-Iron," the following account of which appeared in the *Journal of the Franklin Institute* of July, 1897:

"White iron, with approximately 2·40 per cent. combined carbon and 0·4 per cent. graphitic carbon, is used for the purpose. The castings are placed in a muffle furnace, in which they are subjected to the action of a secret composition (said to be a powerful volatile oxidizing agent) and maintained at a temperature slightly below fusion for five or six hours. The product may be forged and tempered and shows a remarkable increase in tensile strength. The total carbon in the product seems to be the same as in the untreated iron, but combined carbon has been substantially altered into a finely disseminated uncombined carbon.

"Doubts were expressed in the discussion which followed, whether the result was not due entirely to the annealing, rather than to the 'medicine.' The prolonged annealing was thought to be a sufficient explanation of the facts. The process is in commercial operation in a large foundry in Philadelphia, producing hatchets, hammers, etc."

The *Journal of the Franklin Institute* for September, 1900, contains an article by Mr. James on the subject, giving abstracts of results obtained from daily business practice, extending over a considerable period of time; but though these investigations were made for the guidance of commercial operations, they seem to be of sufficient metallurgical interest to justify their presentation.

Mr. James states that the irons used were all of Bessemer quality, the melting charges consisting of a mixture of gray and white irons, of which the following is an average analysis:

	C.C.	G.C.	Si.	Mn.	S.	P.
White iron	3·50	·50	·50	·20	·08	·08
Gray iron	·50	3·50	1·30	·30	·02	·03

"The composition of the charges was regulated by the silicon content, which was made to vary from 1·20 per cent. to ·90 of 1 per cent., the average chemical composition of these mixtures being:

	Per Cent.
Carbon	3·40 to 3·80
Silicon	·90 to 1·20
Manganese	·35 to ·20
Sulphur	·05 to ·04
Phosphorus	·04 to ·03

"The iron was sometimes smelted in a cupola, but generally in an air-furnace. The following is the average chemical composition of a large number of castings:

C.C.	G.C.	Si.	Mn.	S.	P.
3·02	·47	·78	·12	·05	·04

The weight of the castings ranged from a ½ ounce to 2,000 pounds and over. The time required to effect the change varied from three and a half to ten hours from the time the castings had attained their full temperature.

"The temperature at which the change takes place in castings of this description lies between the melting point of silver and copper, and may therefore be approximately taken at 1,850° F.

"The change of carbon in castings subjected to the annealing process, though gradual, is co-extensive throughout any given cross-section of the casting; no hard center or core of white iron, surrounded by softer metal, having ever been observed in any of the castings examined. No matter at what period the annealing may have been arrested, the total surface of any fracture always showed a similarity in the condition of the metal, provided the composition of the metal was homogeneous and the heat-treatment had been applied equally to all parts of the casting."

This agrees perfectly with my own observations, and it constitutes, moreover, a very interesting and important feature, differing from malleable-iron castings, where a progressive change occurs; the central portion of a malleable-iron casting is sometimes found to be practically unaffected by the heat-treatment as to the total carbon, and unless the casting is very thin, the conversion is in fact never uniform

throughout the section. The same law of progressive change in the proportion of carbon obtains in "case-hardening" of steel, though the operation is the reverse, *i. e.*, carbon is imparted to, instead of withdrawn from, the metal.

The following analyses before and after annealing, given by Mr. James, show very clearly, that the only change effected by the heat-treatment is in the condition of the carbon:

	C.C.	G.C.	Si.	Mn.	S.	P.
Before annealing . . .	2·60	·72	·71	·110	·045	·039
After annealing	·82	2·75	·73	·108	·040	·039

Mr. James says: "I wish however to say that, although, for convenience, the term graphite is employed in stating the analyses of these castings after annealing, the condition of the carbon differs very materially from graphite, either as found free in nature or as solidified out from gray iron during cooling. . . . The carbon thus formed is evidently identical with what Ledebur has called 'tempering graphite carbon,' and is an allotropic form of graphite, and not merely amorphous carbon."

Mr. James states that both silicon and manganese exert great influence upon the carbon during the annealing process. "The presence of silicon being a necessary condition to the carbon change. In low silicon iron it is very difficult, and in some cases impossible, to effect the carbon change, no matter how long the iron is exposed to the heat-treatment."

My original investigations did not indicate that manganese possessed any very marked influence on the carbon change in this process, though I am well aware that manganese, especially in the form of ferro-manganese, added in very small quantity to molten car-wheel iron, exerts a marked effect upon the chill and on the relative proportion of combined and graphitic carbon. It is a fact, however, that low silicon irons are usually low in manganese, and this, I think, is the reason why Mr. James was led to infer that manganese facilitates the carbon change in the annealing process.

Mr. James gives no records of strength of the white-iron castings converted by him into gray iron by annealing.

Before proceeding to the consideration of other features I desire to call attention in passing to one point which may, I think, have practical value, especially in the manufacture of chilled cast-iron car-wheels.

It has long been known that wheels having approximately the same depth of chill on their treads wear very differently in service: some retain their hard surface until the white-iron tread is gradually worn away evenly all around the wheel; others become soft in spots very quickly, necessitating removal from service long before the wheel has lived its proper life.

We know that the action of the brakes on the wheel heats the tread, and it seems to me not unlikely, from the foregoing observations, that when the silicon exceeds a certain amount, say 0·7 per cent. in any wheel, a similar kind of annealing of the white-iron tread of the wheel may occur from the heating action of the brakes, thus changing the condition of the carbon, at least to a partial extent, causing the chilled tread to become much softer than would happen under similar conditions where the wheel is made of metal containing less silicon.

The most recent investigations bearing upon the subject under discussion corroborate the prior observations fully, and may be found in the *Bulletin de la Société d'Encouragement pour l'Industrie Nationale*, Paris, March 31, 1902, under the title, "Sur l'Equilibre des Systemes Fer-Carbone," by G. Charpy and L. Grenet.

The authors call attention to the investigations of M. Bakhuis Roozeboom on an interpretation of known facts relating to the constitution of metals formed of iron and carbon, published in the *Bulletin de la Société d'Encouragement*, November, 1900, and also to the investigations of Hugh P. Tiemann on "The temperature limits for the separation of graphite from martensite in pure cast-iron," published in the *Metallographist*, October, 1901.

The authors say: One can believe, then, as appears to be admitted by Mr. Tiemann, that the abundant separation

of graphite, observed by Mr. Royston, was due to the presence of silicon in the white-iron castings employed.

We have made a great many experiments on this point, and we direct attention in particular to the results obtained on five samples of iron containing practically the same percentage of total carbon and in which the other elements are found only in small proportions, except the silicon which exists in variable quantities.

The following table gives the composition of these specimens:

No.	Carbon.	Silicon.	Manganese.	Sulphur.	Phosphorus.
1	3·60	0·07	0·03	0·01	trace
2	3·40	0·27	trace	0·02	0·02
3	3·25	0·20	trace	0·01	0·03
4	3·20	1·25	0·12	0·01	0·01
5	3·30	2·10	0·12	0·02	0·01

These samples had been poured into cold water and did not contain any appreciable proportion of graphite, except the last, where we found 0·20 per cent. Fragments were subjected to annealing, more or less prolonged, at different temperatures. Six tables are given showing the length of time of each treatment, the exact temperatures, and the proportionate change of combined carbon into graphite for each specimen.

The following conclusions are reached: they are announced didactically as laws and may be so accepted.

(1) The separation of graphite commences at a lower temperature as the percentage of silicon is increased in the iron.

(2) The separation of graphite having begun, it continues at a lower temperature than that required to commence the reaction.

(3) At a constant temperature the separation of graphite proceeds at a lower speed according as the temperature is lower and the proportion of silicon is less.

(4) The proportion of combined carbon which corresponds to the equilibrium at a given temperature diminishes when the silicon is increased.

(5) The brochure of Messrs. Charpy and Grenet is embellished with several fine photo-micrographs showing very

clearly the microstructure both before and after treatment. No records are given of tensile strength of the treated specimens and, as it is stated at the beginning of the paper that the white iron specimens were obtained by pouring the metal into cold water, tensile tests could not be made, for the samples were presumably merely small irregular lumps which are far inferior, I think, for such purpose to the uniform ingots of white iron obtained by pouring high chilling metal into heavy iron molds. I have found it easy in this way to obtain ingots of white-iron of any desired length and of suitable sections, the dimensions depending, of course, upon the proportion of silicon contained in the iron poured. By using a flat ingot mold made of thick cast-iron plates I have obtained flat ingots 5 x 3 x ½ inches of perfectly white iron and containing as much as 2 per cent. of silicon. These high silicon white-iron ingots or plates are very readily converted into gray iron by annealing.

Although I consider it a misnomer to call castings, such as hatchets, axes, etc., made from white iron changed to gray iron by heat-treatment and subsequently hardened on cutting edges, steel castings, they are certainly very different from true malleable-iron castings or from ordinary gray-iron castings, possessing qualities more closely resembling steel.

When the process is carefully and intelligently conducted the product is reliable, but prejudice has been developed by the fact that some of the manufacturers have not thoroughly understood the underlying principles and have turned out castings imperfectly converted. It is, of course, much easier to make perfectly white-iron castings from metal very low in silicon, but, as I have here shown, such metal is unsuitable for the subsequent conversion by heat-treatment into gray iron, and this I believe to be the main cause of many failures.

So far as I know there are no valid patents covering the process of heat-treatment of white-iron castings for conversion into dense gray iron of high tensile strength, capable of being forged and tempered, by simply changing the condition of carbon without removing any of the original component elements.

As the process of converting white-iron castings into malleable iron is well understood and has been carried out on a large scale for many years, I have not thought it necessary to allude to this product further than to show that it is radically different from the white-iron castings containing all of the carbon of the original metal before the heat-treatment. Good malleable-iron castings are ductile and may be bent almost double and twisted, while cold, without breaking, if the section is light enough to permit of complete malleableizing, but annealed white castings cannot be thus bent, even when completely converted into gray iron.

It is true, that since the discovery of the fact that hard and brittle white-iron castings may be changed by simple heat-treatment into strong soft gray-iron castings, some makers of malleable castings modify their old methods and practically rely upon heat-treatment to anneal their castings without placing them in oxidizing material, as formerly, to remove the carbon, but such heat-treatment does not and cannot make true malleable-iron castings. In other respects, also, converted white-iron castings, containing all of the original carbon, differ in physical properties from malleable-iron castings from which a large portion of the carbon has been removed.

In conclusion, I would say that if we can eliminate the false name of "steel" which has been given to converted white-iron castings, a distinct advantage will have been gained, for I believe that the new metal is worthy of taking a special place in the metallurgical arts, and I anticipate extended practical applications of the process as knowledge of the proper methods of heat-treatment and of the valuable properties (as well as the equally marked limitations) of the metal shall become better known and appreciated.

PHYSICAL SECTION.

Stated Meeting, held April 24, 1901.

The Contributions of H. F. E. Lenz to the Science of Electromagnetism.

By W. M. Stine, Ph.D.

PART I.

Modern science can scarcely be said to have found a place in its manifold activities for purely historical research of its true beginnings, and the subsequent experimental or analytical development of its fundamental subjects. Such a statement as this obviously can only be true when it is accepted in a wide sense; for the careful reader will at once recall much admirable historical matter woven more or less incidentally into treatises such as "Preston's Theory of "Heat" or "Light," where it forms an integral part of the discussion; or in a few choice monographs and memoirs; and again especially, German scholarship has supplied such historical works as Rosenberger's "Geschichte der Physik." Though for the general reader the usual historical treatment is commonly adequate, a more exacting person readily finds, upon looking up the historical development of almost any line in science, that the available information is by no means consecutive or sufficiently complete to enable the essential progress of the subject to be followed.

Selecting, as is done in this paper, the subject of electromagnetism, these general remarks are far more applicable to it than to inorganic chemical science, for instance, for reasons that are readily apparent. There have not lacked books of varied gradations of pretensions which have borne the generic name of "Electricity and Magnetism;" nor have definite histories of electricity been wanting, such as Albrecht's; and, if this were not sufficient, popular works, such as Trowbridge's "What is Electricity?" have insistently enforced their historical story upon the reader. And

Fleming, also, in the "Alternate Current Transformer," has essayed a partial history of electromagnetism; and not only are Faraday's researches available in greatest detail, but the reader has not far to go to find an almost equally detailed account of the experiments and conclusions of Joseph Henry.

Yet against all this may be brought the assertion that the essentially complete and philosophically considered history of the subject of electromagnetism remains to be written. The reason, if one need be sought for this condition, is at once apparent; the rapid development and extended applications of electromagnetism have continually absorbed all available knowledge of the subject for its own advancement, and have more or less completely diverted those fitted for the task from the scholarly labor of historical research to the more popular and alluring field of experiment and extension of the boundaries, real or supposed, of the subject.

Almost at the very outset of scientific historical study the reader is made aware of a singular tendency to be traced in the nomenclature with which he is dealing; and this tendency is the designation of the fact by the name of the discoverer of the phenomenon. It is now Ohm's law, or again Lenz's law that confronts the reader. He measures resistance with the Wheatstone bridge; or perhaps he uses a Kelvin balance or a D'Arsonval galvanometer. He can scarcely perform the simplest experiments without thus materializing the names of past or present worthies. However irrelevant this may seem at first, consideration will show that it is in reality germane to the subject.

The labors of the scientist lack much, or almost wholly, the expression of the individual. The architect may use his powers and acquired skill and the finished building will be the expression of himself through his craft; and it will be truly an expression of the individual, for the design partakes of his personal mode. No other could have designed just such a structure; the particular building could not have been constructed had he not had existence. This necessity for the expression of the individual is especially realized

for the author through the medium of verse; or for the artist as he embodies part of his own self in the statue.

With the scientist, the case is radically different. Nature is impersonal and the fact is not changed nor the phenomenon influenced by the labors of any student, or the experiments of any scientist. Perhaps these things are unconsciously recognized, even by the most mechanical and artisan-like scientist, and it is their recognition which has induced a partially organized reparation by the wholly artificial means of assigning the origin of any branch of science in particular to that one whose work stands first in point of time; very much as if the science were in any sense the product of the creative genius of the experimenter.

The history of science, however, fails to show that such a function exists between our knowledge of the facts of nature, and that one who has brought them to our notice. Almost invariably a fact of nature is suggested by some happy accident, and the scope of the development of the natural phenomena being necessarily limited, one man as well as another is able to guide the course of development. Even if the matter of discovery or development is in part intellectual and so anticipatory, the mental processes that lead on one investigator are not in their nature different from those possessed by other minds similarly trained and directed in attention, and equally skilled. Man, in other words, in the acquisition and extension of scientific knowledge, plays the part only of a recipient, and in no sense that of a creator; he can ply the part of the manual or intellectual artisan, but in no respect can he attain to being an artist.

Ohm's law has already been offered in evidence. This law, which defines in what magnitude the current is a function of the electromotive force and the resistance, is obviously a particular instance of a perfectly general relation; and experiments with electrical currents could not have proceeded to any extent without revealing the necessity for such a law, and eventually establishing it. The individual experimenter phrasing and establishing such a law was simply the first one in point of time. Now, whether the virtue

of having been first in point of time will justify encumbering the spoken and written phrasing of a law with the name of an individual need not be enlarged upon, as it is too obvious.

This law was enunciated by Ohm in 1827;* but the relation was partially anticipated by Henry Cavendish in 1781† and perhaps by others; and it was certainly independently discovered by Joseph Henry.‡ So, whether Ohm had formulated this relation or not, the law would assuredly have been established prior to 1835. More recent instances are not lacking. The name of Hertz has thus far been inseparably connected with certain phenomena of the stressed field surrounding an electrical charge whose equilibrium has been disturbed. The researches of Hertz began at the suggestion of von Helmholtz in 1879 and were later resumed in 1886. Yet the phenomena were anticipated long before; and whether Hertz had developed our knowledge of them or not, the increased attention paid to alternating current phenomena would very quickly have led investigators to their full recognition. If nothing else had done so, the protection of long power lines against lightning would alone have discovered the Hertzian phenomena.

This unphilosophical and mistaken zeal has resulted in encumbering science with an extensive vocabularly of a reminiscent and biographical character. From the "Peltier effect" to the "Hall" or "Zeeman effect" is a monotonous list of these meaningless, terse and unintellectual symbols, which science would do well to expurgate from its technology.

The beginnings of the science of electromagnetism strikingly exhibit this phase of the impersonal character of scitific work; and if the development of this science is broadly considered, it shows convincingly how slight is the influence of the supposed genius of the investigator. In the history of this subject there is found a record of at least

*G. S. Ohm, Die galvanische Kette mathematisch bearbeitet. Berlin, 1827.

†The Cavendish Researches, Arts. 574–5, 629, 286.

‡Consult Electrical Engineer, Vol. XVII, 1894, p. 297.

several persons making the same discoveries independently, and endeavoring to derive the same laws from the same trend and relations of phenomena involved. It seems that the germ of a new advance in thought, or a generalization, may be abroad and working in the minds of men, and is their common possession; it appears now in one place and again in another without any apparent common stimulus, which would be adequate to produce such a unity of affection. At the most the investigator, even of the highest talent, can but anticipate the labors of others by a longer or shorter period, can exhibit a little more enterprise and initiative than his fellows; but the facts and laws of nature will ultimately be possessed whether one man or another discovers them. The relation of the investigator to the development of science is rather that of the skilled and learned workman; and while honoring the labors of the investigator and acknowledging his essential relation toward the spread of science, it must be conceded that the real scope and play of genius is not in the experiment and investigation, but rather he is the genius *who builds upon facts the philosophical system of their laws.* In the subject of electromagnetism it is Clerk Maxwell who does this so voluminously rather than luminously, for the researches of Faraday and Ampere*, and Franz Neumann for the results of the work of Lenz.†

Among us the work of Lenz has not received the full recognition to which it is entitled. He is known in a very general way as the one who phrased the law bearing his name. Yet the relation which his work bears to the development of electromagnetism is so important that it merits, even at this late day, at least a brief presentation. To this end the present paper will endeavor to present an outline of the researches of Lenz and place these in their historical sequence or precedence, as the case may be, with the labors of those who are fully accredited with the discovery of the phenomena of electromagnetism. This effort was imme-

* Clerk Maxwell: Electricity and Magnetism; Vols. I, II.

† Die mathematischen Gesetze der inducirten elektrischen Ströme, 1845.

diately suggested by a monograph on the researches of Lenz, written by W. Lebedinsky, and published in the St. Petersburg "Electrichistuo" in 1895.* While the present account and estimate of Lenz and his work has been derived from his own published articles, yet the monograph by Lebedinsky has been consulted, that the writer may have the advantage of an estimate of Lenz's researches and contributions, made by a scientist of his own country and persuasion.

By many it has been accepted that perhaps all of the later developments and applications of electromagnetism may be attributed in point of origin to the illustrious investigations of Faraday, especially. But such a view is not supported by the facts in the case. As has already been stated, the phenomena discovered by Faraday were in no sense peculiar to the man, such that had he failed to ascertain them the world would inevitably have been the poorer for their lack. The immediate beginnings of the science of electromagnetism date back from the classical experiments of Oersted in 1819. When, after his famous experiment, it was understood that an electrical current would induce magnetism, the possibility of the converse action taking place seemed to have occurred to many scientists, and slowly to have matured to a conviction.

In order to appreciate the work of Lenz with exactness, something more is needed than the mention of its day and year in the succession of historical data of the discoveries and developments in electromagnetism. It will be necessary to revive something of the scientific atmosphere and feeling of those days, and to place the mind in sympathetic touch with the master-thoughts of those times which centered about the development of electricity from magnetism. To the contemporaries of Faraday, Henry and Lenz this conception was as pregnant with enthusiasm and expectation as the present-day thought of the direct production of electricity from carbon. For the writer no means of gaining the story of those days of wonderful discovery has been

* Translated for the writer by Mr. Stone, of Chicago.

so vital and truthful as the reading of the simple narratives of experiments by which Faraday and Henry, especially, announced to the world the experimental demonstration of the scientific anticipation of those years. And since it cannot better be told, the original articles will be quoted here at considerable length. The account by Prof. Joseph Henry will first be given; not that preference is accorded him from national prejudice, but that he is more frank and generous in the recital.

The famous contribution* of Henry begins: "Although the discoveries of Oersted, Arago, and others have placed the intimate connection of electricity and magnetism in a most striking point of view, and although the theory of Ampere has referred all the phenomena of both these departments of science to the same general laws, yet until lately one thing remained to be proved by experiment in order more fully to establish their identity, namely, the possibility of producing electrical effects from magnetism. It is well known that surprising magnetic results can readily be obtained from electricity, and at first sight it might be supposed that electrical effects could with equal facility be produced from magnetism; but such has not been found to be the case, for although the experiment has often been attempted, it has nearly as often failed.

"It early occurred to me that if galvanic magnetism, on my plan (see Vol. XIX, *Silliman's Journal*, page 400), were substituted for ordinary magnets, in researches of this kind more success might be expected. Beside their great power, these magnets possess other properties, which render them important instruments in the hands of the experimenter—their polarity can be instantaneously reversed, and their magnetism suddenly destroyed or called into full action, according as the occasion may require.

"With this view, I commenced last August (1832) the construction of a much larger galvanic magnet than to my knowledge had before been attempted, and also made prep-

* This was printed in the appendix to No. 2, Vol. XXII, of *Silliman's Journal*, October, 1832; the title was, "On the Production of Currents and Sparks of Electricity from Magnetism."

arations for a series of experiments with it on a large scale in reference to the production of electricity from magnetism. I was, however, at the time accidentally interrupted in the prosecution of these experiments and have not been able since to resume them, until within the last few weeks, and then on a much smaller scale than was at first intended."

Professor Henry then records the statement that he had read in the 117th number of the Library of Universal Knowledge "that the result so long sought after has at length been found by Mr. Faraday, of the Royal Institution." He then quotes in full the announcement from the April number of the *Philosophical Magazine*, under date February 17th, which is given below. He then continues:

"Before having any knowledge of the method given in the above account, I had succeeded in producing electrical effects in the following manner, which differs from that employed by Mr. Faraday, and which appears to me to develop some new and interesting facts. A piece of copper wire about 30 feet long and covered with elastic varnish was closely coiled around the middle of the soft iron armature of the galvanic magnet. (Described in Vol. XIX, *Silliman's Journal.*) The armature thus formed with wire was placed in its proper position across the ends of the galvanic magnet and there fastened so that no motion could take place. The two projecting ends of the helix were dipped into two cups of mercury and these connected to a distant galvanometer by means of copper-wire 40 feet long. This arrangement being completed, I stationed myself near the galvanometer and directed an assistant at a given word to immerse suddenly in a vessel of dilute acid the galvanic battery attached to the magnet. At the instant of immersion the north end of the needle was deflected 30° to the west, indicating a current of electricity from the helix surrounding the armature. The effect, however, appeared only as a simple impulse, for the needle, after a few oscillations, assumed its former undisturbed position in the magnetic meridian, although the galvanic action of the battery, and consequently the magnetic power, was still continued. I

was, however, much surprised to see the needle suddenly deflected from a state of rest to about 20° to the east, or in a contrary direction when the battery was withdrawn from the acid, and again deflected to the west when it was reimmersed."

On the first impression it may seem singular that the announcement of Faraday's success was so long a time in reaching the attention of Henry; but the transmission of news from Europe to America was slow in those days, and beside, Henry was then a professor at a small school, an academy, in the partly isolated town of Albany. As was his custom, he was in this year, 1832, engrossed in experiments during his vacation, and these he conducted in his schoolroom. Partly through preoccupation, partly owing to the slow diffusion of news and to having been at such a distance from a large center, it can be understood that the report of Faraday's success did not reach Henry until he was well on the way toward an independent discovery of the same phenomena. And to appreciate clearly the influence which the announcement could have had in guiding him experimentally, it is interesting to examine the terse extract published in the *Philosophical Magazine** to which Henry refers in his own communication.† The note occurs in connection with a report of the proceedings of the Royal Institution, and reads:

"Feb. 17. *The Conversion of Magnetism into Electricity.*— This long wished-for result has at length been obtained by Mr. Faraday. If two wires *A* and *B* be placed side by side, but not in contact, and a voltaic current be passed through *A*, there is instantly a current produced by induction in *B*, in the opposite direction. Although the principal current in *A* be continued, still the secondary current in *B* is not found to accompany it, for it ceases after the first moment."

A touch of local history is not without interest in this narrative, and it shows to what extent scientists generally were interested in these remarkable phenomena. The en-

* April, 1832, Vol. XI, p. 300.

† Also reprinted in *Silliman's Journal*, No. 2, Vol. XXII, October, 1832, p. 386.

thusiastic interest aroused by Faraday's announcement of his successful experiments was relatively as great as that so recently awakened through the Röntgen-ray phenomena. Prof. A. D. Bache, of the University of Pennsylvania, published in the *Journal of the Franklin Institute* * a philosophical summary of Faraday's experiments and their extension through Nobili's researches; and what is more interesting, he prints two letters from a certain J. Saxton, of Philadelphia, which were written from London in April and May, 1832, to one Isaiah Lukens. Through these letters especially an insight is gained into the exact feeling which had taken possession of English scientists.

In coming to the recital of Faraday's work, he has not introduced so much of the personal element into the narrative of his experiments.† He is more scientifically formal, and prefaces his account with a definition of the sense in which he proposes to use the term "induction." After briefly referring to some phenomena of induction in magnetism and static electricity, he remarks:

"Whether Ampere's beautiful theory were adopted, or any other, or whatever reservations were mentally made, still it appeared very extraordinary, that as every electric current was accompanied by a corresponding intensity of magnetic action at right angles to the current, good conductors of electricity, when placed within the sphere of this action, should not have any current induced through them, or some sensible effect produced equivalent in force to such a current.

"These considerations, with their consequence, the hope of obtaining electricity from ordinary magnetism, have stimulated me at various times to investigate experimentally the inductive effect of electric currents. I lately arrived at positive results, and not only had my hopes fulfilled, but obtained a key which appeared to me to open out a full explanation of Arago's magnetic phenomena, and also to

* July, 1832, p. 66.

† Read November 24, 1831, and published in the "Philosophical Transactions of the Royal Society," Part I, 1832, pp. 125–163. Also in Vol. I, "Faraday's Experimental Researches in Electricity," pp. 1–41.

discover a new state which may probably have great influence in some of the most important effects of electric currents."

Faraday's way to success in endeavoring to establish his preconceptions and hopes lay through many failures and partial results, while it may be recalled that Henry brilliantly proved his grasp on the same thought by one simple and decisive experiment, the like of which, it will be seen, Faraday had been led to in the end.

It seems that the thought of the generation of electricity from magnetism had materialized itself into a general experimental idea which was similarly held at least by many scientists. This idea in short, was, that the magnetism which accompanied a voltaic current in a wire *A*, should awaken by induction a voltaic current in a wire *B*, placed parallel with it. And we now understand that the reason for the failure of these early experimenters did not proceed from false premises but from the use of crude and insensitive galvanometers. The criterion for success briefly was not some far-seeing grasp of a vague principle, but a mechanism sufficiently powerful to make the phenomenon of induction evident through the crudeness of the then experimental apparatus. Faraday states this to some effect in this "corrective chronological note" written in April, 1832.* "I experimented on this subject several years ago, and have published results.† The following also is an extract from my note-book dated November 28, 1825: 'Experiments on induction by connecting wire of voltaic battery; a battery of four troughs, ten pairs of plates, each arranged side by side—the poles connected by a wire about 4 feet long, parallel to which was another similar wire separated from it only by two thicknesses of paper, the ends of which were attached to a galvanometer—exhibited no action, etc., could not in any way render any induction evident from the connecting wire.' The cause of failure at that time is now evident (April, 1832)."

Faraday's crucial experiments can only be given more

* Experimental Researches, p. 41.

† *Quarterly Journal of Science*, July, 1825, p. 338.

or less in brief outline, though their elegant logical arrangement in his paper would merit their quotation at length. Among them were:

(1) About a cylinder of wood, some 26 feet of 0·05 inches diameter of copper-wire was wound alternately with twine for insulation. (It is noteworthy that Faraday had not come to the happy idea of insulating the wire as Henry had done). This helix was then covered with calico and a second helix similarly applied, and so on until twelve such coils had been wound. Two separate circuits were formed through these coils by connecting the alternate helices in series. Two wires each of 155 feet were thus coiled so that their electrical circuits were parallel and similarly directed, though we are not informed of the number of turns in the compound helix. One circuit was connected with a galvanometer and the other with a powerful voltaic battery. It is recorded "that not the slightest sensible deflection of the galvanometer could be observed."

(2) "A similar compound helix, consisting of six lengths of copper and six of soft iron-wire was constructed. The resulting iron helix contained 214 feet of wire, and the resulting copper helix 208 feet; but whether the current from the trough was passed through the copper or the iron helix, no effect upon the other could be perceived at the galvanometer." This experiment shows especially how insensitive Faraday's galvanometer must have been, otherwise one cannot understand how he failed of some deflection.

(3) "Two hundred and three feet of copper-wire in one length were coiled around a large block of wood; other 203 feet of similar wire were interposed as a spiral between the turns of the first coil, and metallic contact everywhere was prevented by twine. One of these helices was connected with a galvanometer and the other with a battery of 100 pairs of plates 4 inches square, with double coppers and well charged. When the contact was made, there was a sudden and very slight effect at the galvanometer, and there was also a similar slight effect when the contact with the battery was broken." The partial success in this experiment

seems to have been due to the excessive battery used, which was many times as powerful as that employed in the first test.

After having established this "volta-electric induction," as he calls it, Faraday proceeded to the "evolution of electricity from magnetism."

(4) This experiment is so well known and so similar to that already enlarged upon in connection with the work of Henry that it may be very briefly summarized. "A welded ring was made of soft, round bar iron, $\frac{7}{8}$ of an inch in thickness, and the ring being 6 inches in external diameter." Two compound helices were wound as above on the ring opposite each other in position. "The helix *B* was connected by copper-wires with a galvanometer 3 feet from the ring." The helix *A* was "connected with a battery of ten pairs of plates 4 inches square. . . . The galvanometer was immediately affected, and to a degree far beyond what has been described when with a battery of tenfold power helices *without iron* were used; but though the contact was continued, the effect was not permanent, for the needle soon came to rest in its natural position, as if quite indifferent to the attached electromagnetic arrangement. Upon breaking the contact with the battery, the needle was again powerfully deflected, but in the contrary direction to that induced in the first instance."

A second detail of historical value occurs in the now celebrated paper of Faraday, and it relates to the working conception which he had developed to generalize the phenomena of electromagnetic induction, whereby he had treated the magnetic field as if it were made up of curved lines of force or of "magnetic curves." It is at this point that the work of Faraday becomes closely associated with that of Lenz, and the discussion of these lines of force may preferably be deferred until it is called up by the strictures which Lenz placed upon them.

But just here where the action in the development of the phenomena and laws of electromagnetism and electromagnetic induction pass over from the labors of Faraday and Henry to the investigation of Lenz, it seems not inap-

propriate to quote the impromptu lines of Herbert Mayo, leaving to the reader to decide whether they may not more appropriately be applied to the initial experiment of Henry than to the labors of Faraday which they originally celebrated.

"Around the magnet, Faraday
Conceived voltaic lightnings play;
Yet could not draw them from the wire!
He learned a lesson from the heart:
'Tis when we meet, 'tis when we part,
Breaks forth electric fire!" *

End of Part I.

Correspondence.

WATER-SUPPLY IN ANCIENT JERUSALEM.

To the Editor:

In Dr. Leffmann's interesting paper on the water-supply in ancient Jerusalem (this volume, pp. 103–107), the translation of the Siloam inscription discovered in 1880, being derived from the French, does not make it clear that the tunnel was begun from the two ends. The translation of the inscription given in Bennett H. Brough's "Treatise on Mine Surveying" (ninth edition, 1902) is as follows: "[Behold] the excavation! Now this is the story of the tunnel: While the miners were still lifting up the pick towards each other, and while there were three cubits [to be broken], the voice of one called to his neighbour, for there was an excess in the rock on the right. They rose up—they struck on the west of the tunnel; the miners each to meet the other pick to pick. And there flowed the waters from their outlet to the pool for 1200 cubits, and [three-quarters] of a cubit was the height of the rocks over the heads of the miners." B. H. B.

LONDON, February 17, 1903.

To the Editor:

In reference to the above letter, I would like to say that I think that the phrase given in my paper ("the borers worked their picks in opposing directions, and there were 3 cubits to break through") indicates that the work was carried out by two gangs working in opposite directions. Regarding the word translated "blind alley," it must be noted that the French text reads "accident," instead of which Dr. Jastrow, who gave me the reference, suggested "cul-de-sac." I adopted the suggestion and translated as above. I incline now to the view that the best reading would be "overlap," indicating that the gangs, not meeting exactly, passed each other for a short distance. Hearing each other through the intervening partition they broke it through.

HENRY LEFFMANN.

PHILADELPHIA, March 20, 1903.

*Altered from Gladstone's Life of Faraday, p. 200.

Notes and Comments.

COOPER HEWITT INTERRUPTER AS AN AID IN WIRELESS TELEGRAPHY.

Each advance in wireless telegraphy has emphasized the inefficiency of the spark-gap interrupter, and this element has threatened to be the weak factor in the commercial development of aerial transmission. In the Marconi trans-atlantic experiments the power required at the disruptive gap was enormous in comparison with the presumable quantity of energy radiated from the antennæ, and a serious incident of the great local disturbance thereby set up has been the adverse effect on telephonic service over a wide range, which forecast trouble for the exploiters of commercial wireless telegraphy. It is, therefore, a matter of unusual interest to learn that an interrupter for an oscillating circuit has recently been devised which not only very greatly reduces the draft on the source of electrical energy but possesses most valuable properties with respect to exact control, and at the same time is extremely simple in form and application.

In wireless telegraphy the spark-gap oscillating circuit has heretofore been employed, either in connection with the simple induction coil or the disruptive gap In his studies on the mercury vapor tube, it occurred to Mr. Peter Cooper Hewitt that the "electric valve" property of the vapor tube, which he has employed in his static converter, could be applied to the oscillating circuit. This application he has succeeded in carrying out in a most successful manner.

Briefly stated, the spark-gap of the oscillating circuit is replaced by a mercury vapor tube in parallel with a condenser. Assuming that the immediate source of electrical energy is a transformer, in the transformer secondary in series are a condenser and the primary of the antennæ-ground circuit, the condenser being shunted by a vapor tube. The tube does not differ in principle from the usual Cooper Hewitt vapor tube, though naturally of a somewhat different form, owing to its different application, and the nature of the work to be performed. The transformer secondary voltage may range between 10,000 and 20,000 volts.

The fundamental advantage of this interrupter is the enormous speed of interruption that may be attained, and the absolute control of this speed. Moreover, by proper design and adjustment, any given rate of adjustment can be secured. With the disruptive spark there is a limit to the efficient rate of interruption fixed by the time required for the condenser to clear itself, and this rate, as well as the total effect, is variable, owing to the mobility of the arc, the condition of the knobs with respect to polish, etc. This latter consideration does not apply to the mercury electrode surface, and the vacuum discharge is not subject to similar fluctuations. It follows that with this new type of interrupter it is possible to create and maintain continuously oscillations of an absolutely definite character, the great importance of which consideration with respect to wireless telegraphy is obvious.

The practical advantages of the interrupter are no less evident. The efficiency is very high, the loss being about proportional to the drop of about

14 volts in the tube, and in a circuit of 10,000 volts this amounts to but a small fraction of 1 per cent. The device, consisting merely of a glass tube or bulb with sealed-in electrodes, is inexpensive, and in case of breakage can be immediately replaced by another in the same manner as an incandescent lamp.—*Electrical World.*

WIRELESS TELEGRAPHY AND THE "ST. LOUIS."

The painful uncertainty attending the belated "St. Louis," of which nothing was heard, from the time she left Cherbourg until she was sighted at Nantucket, a week overdue, suggests that for passenger ships at least, the time will be welcomed when every vessel is equipped with a wireless telegraph outfit. Although none of the vessels so equipped would be capable of repeating Marconi's feat when he communicated from one of the vessels of the American Line over 1,500 miles at sea with the powerful Poldhu station, a range of say 200 miles should be quite within commercial practicability. Considering the crowded condition of the various steamship lanes across the Atlantic, it would be impossible, were all passenger ships so provided, for a vessel to remain unspoken for more than a day or two at the longest; and a liner disabled in mid-Atlantic should be able to communicate from ship to ship with her home port and news of her trouble be made known, long before the day set for her arrival. In this way an enormous amount of anxiety could be spared to relatives and friends on the all-too-frequent occasions when transatlantic vessels are disabled. Indeed, we consider that just as soon as wireless telegraphy has been placed on a thorough commercial basis, it would be quite within reason for a law to be passed requiring all ships to install some one of the wireless telegraph systems which will be on the market.—*Scientific American.*

Book Notices.

The Alaska Frontier. By Thomas Willing Balch, A.B. (Harvard), member of the Philadelphia Bar. Philadelphia: Allen, Lane & Scott; large 8vo, pp. 212.

This book is an exhaustive study of the Alaska boundary question, about which Mr. Balch published a paper, "The Alasko-Canadian Frontier," in the *Journal of the Franklin Institute* for March, 1902. To collect his information Mr. Balch traveled as far west as Alaska and as far east as St. Petersburg. This book gives a complete account up to 1903 of all the facts relating to the boundary question, including the negotiations that preceded the Anglo-Muscovite Treaty of 1825; the subsequent official acts of the various interested Governments, such as the turning back by Russian officials in 1834 of the British brig "Dryad;" the events leading up to the purchase of Alaska by the United States, including a letter on that subject by Frederick W. Seward, the son of Secretary Seward; the International Law governing the case; and reproductions of twenty-eight maps, some of them very rare. The author proves conclusively that up to the present time the Canadians have not advanced in support of their contentions anything but "a nebulous maze of

alleged facts," and their whole argument is founded upon a quibble. He shows that the Canadians do not rebut the evidence afforded by the many Canadian, English, French, German, Russian and other maps which mark the frontier line claimed by the United States, and calls special attention to the fact that in 1901, three years after the Quebec Conference, the English Government supported, through its official geographers, the British Admiralty, the claims of the United States by giving her a continuous lisière above 54° 40′. W.

Calorimetry. By Frank H. Bates. 12mo, ix+127 pp. Philadelphia: Philadelphia Book Company, 1902. (Price, $1.00.)

A practical treatise on the determination of calorific value of fuels in steam-boiler practice. The subject is treated in a readily comprehensible manner. W.

Bricklaying. By Owen B. Maginnis. 8vo, pp.85. New York: Author, N.D. (Price, $2.00.)

This work is a practical treatise on the art of bricklaying, intended for the use of engineers, architects and builders. It gives in concise form and with numerous illustrations the best modern practice of the art, and should be a useful compendium for those having occasion to obtain information on the subject of which it treats. W.

The Slide-Valve and its Functions, with special reference to modern practice in the United States (with ninety diagrams and illustrations.) By Julius Begtrup, M.E. (8vo, vii+143.) New York: D. Van Nostrand Company. London: E. & F. N. Spon, 1902. (Price, $2.00.)

The author has endeavored in this work to explain and illustrate the fundamental principles of valve mechanism by new graphical methods, and describes and analyzes a number of special valve constructions to exhibit how the exacting conditions of higher steam-pressure and higher speed are now met by modern engine builders.

The several chapter-heads read as follows: I. The common slide-valve; II. Improved slide-valves; III. Four-valve systems; IV. Independent cut-off; V. The slide-valve on pumps; VI. Angularity of connecting-rod and eccentric rod. W.

Franklin Institute.

[*Proceedings of the Stated Meeting held Wednesday, March 18, 1903.*]

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, March 18, 1903.

President JOHN BIRKINBINE in the chair.

Present, 121 members and visitors.

Additions to membership since last report, 16.

Mr. A. D. Bramhall, on behalf of the American Brazing Company, of Philadelphia, read a paper describing the process of brazing iron castings, invented

by Herr Pich, a German inventor, and exhibited a number of specimens, large and small, of cast-iron articles that had been repaired by the process. An experimental demonstration of the process was also made.

The subject was freely discussed.

Mr. Frank A. Brunner, of Philadelphia, read a brief communication describing the Keystone Photographic Printing Machine, which was followed by an exhibition of its operation. The source of illumination in this apparatus is an electric arc lamp of special design intended to afford the maximum quantity of the actinic rays, and the object sought to be accomplished is the rapid and economical printing of photographic negatives, whether films or glass, independent of weather conditions.

Adjourned.

WM. H. WAHL, *Secretary.*

Committee on Science and the Arts.

[*Abstract of proceedings of the stated meeting held Wednesday, February 4th, and the adjourned meeting Wednesday, February 11, 1903.*]

MR. CHAS. E. RONALDSON in the chair.

Mr. Chas. E. Ronaldson, the newly elected Chairman, assumed the chair. The retiring Chairman, Mr. Thos. P. Conard, was accorded a vote of thanks for his services.

The following reports were adopted:

(No. 2230.) *Speed-Controller.*—Consolidated Machine Specialty Company, Boston, Mass.

ABSTRACT.—The method of obtaining variable speed generally in use is the well-known pair of steep cones with the shifting belt. This method is not at all adapted to present conditions, and machine-tool builders are striving to replace the steep-cone method by something of a more efficient character.

The device here referred to consists of two cast-iron disks, one keyed to the shaft and the other to a quill rotating on this shaft. Two friction-wheels which separate these disks may be rotated by means of a handle around a point which is also the center of the circles formed by the cast-iron disks; a pulley is keyed to this shaft and one to the quill, and the two disks may be forced together by means of a friction-clutch operating through a spiral-spring. A ball-bearing washer reduces the friction due to the thrust, to a minimum.

The operation of the countershaft is extremely simple, the power being delivered to one of the pulleys and taken off at the other, the relative speeds depending upon the position of the friction wheels. These wheels have a rawhide face and run on antifriction bushings made from wood which has been boiled in a composition of paraffin and other ingredients. These wheels do not require any lubrication, and as the bearings are all of the ring-oiler type, but little attention to this detail is required. The pressure on the fric-

tion-disks can be adjusted to any desired amount by means of the friction-clutch.

The report then proceeds to discuss the experimental trials of the device made under the sub-committee's directions, and concludes with the recommendation of the Edward Longstreth Medal of Merit to the inventor of the device, Mr. H. H. Cummings, for the development and introduction of a device called a speed-controller, used in connection with a source of power of constant speed as a means of obtaining variable speed on the driven shaft. [*Sub-Committee.*—Charles Day, Chairman; Lucien E. Picolet.]

(No. 2249.) *Magnetic Clutches.*—Bion I. Arnold, Chicago, Ill.

ABSTRACT.—The system devised by Mr. Arnold has been planned with the view of building direct-connected electric-power plants which should retain the flexibility of operation of the old-style belted plants, with the advantages of direct-connected construction..

By flexibility of operation is meant, that in case of an accident to an engine the generator run by that engine can be run by another engine.

The report proceeds to describe in detail the various applications of the system, which would not be intelligible without the aid of illustrations. The award of the Edward Longstreth Medal of Merit is made to applicant for the originality and skill displayed in the invention. [*Sub-Committee.*—Francis Head, Chairman; Arthur Falkenau, Charles Day.]

(No. 2267.) *Device for Measuring and Recording the Variable Diameter of Tubes.*—L. Bancroft Mellor, Philadelphia.

ABSTRACT.—The object of this device, which is protected by letters-patent granted to applicant, is to disclose the condition of the interior of boiler-tubes as to scale, blisters and other defects which may increase or diminish the normal diameter.

The variation in relative distance between two measuring points of the instrument is recorded on a revolving disk.

The instrument consists of a tube serving as a frame, mounted in which is a tranverse-wheel, which rotates by contact with the inside of the tube to be measured as the instrument is pushed forward for the purpose of exploration.

By suitable gearing, this wheel rotates a disk on which the recording paper is mounted. A movable finger opposite to the traverse-wheel is mounted in the frame. This finger acts in a lever, causing a reciprocating motion of a rod carrying a pencil which rests on the recording paper, the motion of the pencil corresponding to the reciprocating motion of the finger.

Thus the relative distances between the traverse-wheel and the finger are recorded, and the varying diameters of the center through which the instrument passes are approximately recorded in a sinuous line. . . . Diagrams taken from various boiler-tubes were submitted for inspection, and it was stated that by means of this instrument unsuspected defects in boilers have been detected.

The report recommends the award of the John Scott Legacy Medal and Premium to the applicant. [*Sub-Committee.*—A. Falkenau, Chairman; Henry F. Colvin, Charles Day.]

(No. 2269.) *Horizontal Folding-Door.*—Wm. A. Cross, Chicago, Ill.

ABSTRACT.—The invention is secured by U. S. letters-patent to applicant, No. 663,219, December 4, 1900, and its object is to provide a simple, strong

and efficient sectional counterbalanced door for warehouses and other commercial buildings.

The doors are made of wood, the upper half combining wood-framing with wireglass; also admits the doors to be of corrugated iron upon a suitable modern frame. The doors are hinged at their tops to the doorframe by butt-hinges or rod-shaped pintle and formed by an upper and lower section of subsubstantially equal size, hinged together. The counterbalance-weights are secured by cords or chains which pass over overhead pulleys, thence down either side of the door to the guide-block or pintle-pins at lower end of bottom section of the door. Suitable hand-hasps are fastened upon the lower section of the door.

The Investigating Committee finds this door to be unique, being an improvement upon the swingdoor type; its nearest competitor being the "rolling-steel" varieties, to which it is superior in that it does not depend upon the integrity of its curtain, for the entire covering might disappear, and this frame would still work as before.

The report proceeds to enumerate a number of advantages claimed for this invention, all of which appear to be substantiated.

The report recommends the award of the John Scott Legacy Premium and Medal to the inventor. [*Sub-Committee.*—Charles E. Ronaldson, Chairman; H. R. Heyl, Ernest M. White.]

(No. 2264.) *Process of Purifying Water.*—J. M. A. Lacomme and Walter Lander, New York.

(An advisory report.)

Stated Meeting, March 4, 1903. (No. 2253.) *Speed Variator.*—Lodge & Shipley, Cincinnati, O.

Not adapted to be abstracted without illustrations.

The report grants the Edward Longstreth Medal of Merit to the inventor, Wm. Schellenbach, for the development of a device called a speed variator, being a means of obtaining from a source of power of constant speed, variable speed suitable for driving machine-tools and other apparatus where such variation is required. [*Sub-Committee.*—Charles Day, Chairman; Wilfred Lewis, Lucien E. Picolet, Tinius Olsen.]

(No. 2254.) *Apparatus for Cleansing Water Pipes.*—Norman W. Stearns, Roxbury, Mass. Inventor, Vincenzo Bonzagni.

(An advisory report.)

The following reports passed first reading:

(No. 2219.) *Method and Apparatus for Storing and Transporting Acetylene.*—John S. Seymour, New York. Inventors: Claude, Hess & Fouché.

(No. 2260.) *Hylo Incandescent Electric Lamp.*—Phelps Company, Detroit, Mich.

(No. 2266.) *Kodak Developing Machine.*—Eastman Kodak Company, Rochester, N. Y.

W.